



# AERONAUTICAL ENGINEERING

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A SPECIAL BIBLIOGRAPHY  
WITH INDEXES  
Supplement 76

NOVEMBER 1976

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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# **AERONAUTICAL ENGINEERING**

## **A Special Bibliography**

### **Supplement 76**

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in October 1976 in

- *Scientific and Technical Aerospace Reports (STAR)*
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**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

**NOVEMBER 1976**

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# INTRODUCTION

Under the terms of an interagency agreement with the Federal Aviation Administration this publication has been prepared by the National Aeronautics and Space Administration for the joint use of both agencies and the scientific and technical community concerned with the field of aeronautical engineering. The first issue of this bibliography was published in September 1970 and the first supplement in January 1971. Since that time, monthly supplements have been issued.

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## TYPICAL CITATION AND ABSTRACT FROM STAR

NASA SPONSORED DOCUMENT	N76-11048 #	Georgia Inst of Tech Atlanta	AVAILABLE ON MICROFICHE
NASA ACCESSION NUMBER	STUDY OF VISCOUS FLOW ABOUT AIRFOILS BY THE INTEGRO-DIFFERENTIAL METHOD	Final Report	CORPORATE SOURCE
TITLE	James C Wu and Serangan Sampath	Oct 1975 61 p refs	PUBLICATION DATE
AUTHORS	(Grant NsG-1004)		AVAILABILITY SOURCE
CONTRACT OR GRANT	(NASA-CR-145693)	Avail NTIS HC \$4 50 CSCL 01A	COSATI CODE
REPORT NUMBER	<p>An integro-differential method was used for numerically solving unsteady incompressible viscous flow problems. A computer program was prepared to solve the problem of an impulsively started 9% thick symmetric Joukowski airfoil at an angle of attack of 15 deg and a Reynolds number of 1000. Some of the results obtained for this problem were discussed and compared with related work completed previously. Two numerical procedures were used an Alternating Direction Implicit (ADI) method and a Successive Line Relaxation (SLR) method. Generally the ADI solution agrees well with the SLR solution and with previous results are stations away from the trailing edge. At the trailing edge station, the ADI solution differs substantially from previous results while the vorticity profiles obtained from the SLR method there are in good qualitative agreement with previous results.</p> <p>Y J A</p>		

## TYPICAL CITATION AND ABSTRACT FROM /AA

NASA SPONSORED	A76-10264 #	Hybrid upper surface blown flap propulsive-lift concept for the Quiet Short-Haul Research Aircraft	AVAILABLE ON MICROFICHE
AIAA ACCESSION NUMBER	J A	Cochrane and R J Carros (NASA, Ames Research Center, Moffett Field, Calif)	AUTHORS
TITLE	American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 11th, Anaheim, Calif, Sept 29-Oct 1, 1975, AIAA Paper 75-1220	9 p 5 refs	AUTHORS AFFILIATION
MEETING DATE			NAME OF MEETING
<p>The hybrid upper surface blowing concept consists of wing mounted turbofan engines with a major portion of the fan exhaust directed over the wing upper surface to provide high levels of propulsive lift, but with a portion of the fan airflow directed over selected portions of the airframe to provide boundary layer control. NASA-sponsored preliminary design studies identified the hybrid upper surface blowing concept as the best propulsive lift concept to be applied to the Quiet Short-Haul Research Aircraft (QSRA) that is planned as a flight facility to conduct flight research at low noise levels, high approach lift coefficients, and steep approaches. Data from NASA in house and NASA sponsored small and large scale wind tunnel tests of various configurations using this concept are presented.</p> <p>(Author)</p>			

# AERONAUTICAL ENGINEERING

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## IAA ENTRIES

**A76-38351** Basic strength and trial production tests on a carbon fiber reinforced plastics aircraft rudder surface Y Sakatani and Y Yamaguchi (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan) *Japan Society of Materials Science, Journal*, vol 25, May 1976, p 410-416 8 refs In Japanese, with abstract in English

Models of aircraft rudder sections were fabricated on an experimental basis in the form of carbon fiber reinforced plastics (CFRP) plus aluminum honeycomb sandwich structures Static flexural tests were run on these models, and load-strain curves and load-deflection curves are plotted Carbon fiber reinforcements, epoxy fiber prepregs, and adhesive fibers were investigated, in addition to angle-ply laminating as a fabrication process, assembling via secondary bonding, and process hardware Use of CFRP in the aircraft structure resulted in a roughly 25% weight reduction compared to the aluminum structure, the comparative data are tabulated R D V

**A76-38399** An integral approach to lifting wing theory at Mach one T R Goodman (Oceanics, Inc., Plainview, N Y) *Journal of Engineering Mathematics*, vol 10, July 1976, p 243-261 12 refs Contract No F44620-72-C-0079

An approach to lifting wing theory at Mach one is presented that utilizes an integral method similar to the Karman-Pohlhausen method in boundary layer theory As in any integral method the results obtained are approximate in nature Nonetheless, comparison with experimental data shows good agreement in cases for which experimental data are available The method can easily be used to determine the lift on wings of finite aspect ratio and also to solve transient lifting problems The method is demonstrated by solving for the pressure distribution on a lifting airfoil of arbitrary symmetric cross section, the lift on a wing of rectangular planform, and the transient lift on an airfoil due to a sudden change in angle of attack These cases were chosen to illustrate the versatility of the method and are not meant to be exhaustive of all possibilities The computational time required to obtain numerical results is very small in all cases considered (Author)

**A76-38400 \* #** Potential improvements in turbofan engine fuel economy R W Hines and W O Gaffin (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-666* 7 p NASA-sponsored research

The method developed for initial evaluation of possible performance improvements in the NASA Aircraft Energy Efficiency Program, directed toward improving the fuel economy of turbofan engines, is outlined, and results of the evaluation of 100 candidate engine modifications are presented The study indicates that fuel consumption improvements of as much as 5% may be possible in current JT3D, JT8D, and JT9D turbofan engines Aerodynamic, thermodynamic, material, and structural advances are expected to yield fuel consumption improvements on the order of 10 to 15% in

advanced turbofan engines, with the greatest improvement stemming from significantly higher cycle pressure ratios Higher turbine temperature and fan bypass ratios are also expected to contribute to fuel conservation C K D

**A76-38445** Converting fatigue loading spectra for flight-by-flight testing of aircraft and helicopter components J C Ekvall and L Young (Lockheed California Co., Burbank, Calif.) (*American Society for Testing and Materials, Workshop on Fatigue Loading Spectra, Atlanta, Ga., Dec 10, 1974*) *Journal of Testing and Evaluation*, vol 4, July 1976, p 231-247 22 refs

The paper shows how to convert fatigue service loading spectra into fatigue test spectra to meet the requirements for full-scale fatigue testing of aircraft and helicopter components To conduct a flight-by-flight component fatigue test, the composite fatigue loading spectrum must be specified as a sequence of mean and cyclic loads For this purpose, each continuous loading spectrum is converted to a discrete loading spectrum by selecting the maximum load levels and suitable stepwise loading increments Procedures are described for defining the application of high loads, truncation of low load levels, tradeoff of a fewer number of higher cyclic stress levels for a larger number of lower cyclic stress cycles, and the sequence of applying the individual loads and flights Particular attention is given to the effects of fretting, temperature, rest interval, corrosion, and the frequency of applying cyclic loads S D

**A76-38457 #** Rotating cylinder for circulation control on an airfoil J S Tennant (Florida Atlantic University, Boca Raton, Fla.), W S Johnson, and A Krothapalli (Tennessee, University, Knoxville, Tenn) *Journal of Hydraulics*, vol 10, July 1976, p 102-105 15 refs Contract No N00014-71 A-0121 006

The lift augmentation effect of a rotating cylinder located at the truncated trailing edge of a body is presented A symmetrical airfoil model with a trailing-edge cylinder was tested in a low speed wind tunnel, and the lift produced as a function of cylinder speed was determined for cylinder speeds up to three times the freestream velocity Since the lift was attained at a 0 deg geometric angle of attack, the lift-producing phenomenon is called circulation control, which results from the alteration of the wake region by the spinning cylinder The lift coefficient was found to be a linear function of the ratio of cylinder speed to freestream velocity and reached a value of 1.20 at a speed ratio of 3.0 A comparison is made with a lone spinning cylinder in a crossflow (magnus effect) and the cylinder-forebody combination reported herein The cylinder-forebody pair produces higher values of lift at a given cylinder speed and a linear response in contrast to the nonlinear response of the lone cylinder at low cylinder speeds (Author)

**A76-38458 #** Minimum induced drag of ground effect wings S Ando (Nagoya University, Aichi, Japan) and H Yashiro *Journal of Hydraulics*, vol 10, July 1976, p 106-112 10 refs

Kida and Miyai's theory, which treats theoretically the problem of the minimum induced drag of nonplanar ground effect wings, is refined and extended The gap clearance between the wing tip and the ground is assumed to be so small that the method of matched asymptotic expansions may be used Except for this restriction, this method has a remarkable flexibility in wing front-view geometry The theory is applied to some typical cases such as semielliptic, rectangular, and triangular ground effect wings over flat surface and a

flat plate in a rectangular guide way Special attention is concentrated on the two limiting cases with very high and low front views Kida and Miyai's errors are corrected (Author)

**A76-38481 \*** Analysis and testing of two-dimensional slot nozzle ejectors with variable area mixing sections G B Gilbert (Dynatech R/D Co., Cambridge, Mass.) and P G Hill (Queen's University, Kingston, Ontario, Canada) In Symposium on Jet Pumps and Ejectors and Gas Lift Techniques, 2nd, Cambridge, England, March 24-26, 1975, Proceedings Cranfield, Beds., England, BHRA Fluid Engineering, 1975, p D3-45 to D3-64 7 refs Contract No NAS2-6660

Finite difference computer techniques have been used to calculate the detailed performance of air-to-air two-dimensional ejectors with symmetric variable area mixing sections and coaxial converging primary nozzles The analysis of the primary nozzle assumed correct expansion of the flow and is suitable for subsonic and slightly supersonic velocity levels The variation of the mixing section channel walls is assumed to be gradual so that the static pressure can be assumed uniform on planes perpendicular to the axis A test program was run to provide two dimensional ejector test data for verification of the computer analysis A primary converging nozzle with a discharge geometry of 318 mm x 203 mm was supplied with 0.340 kg/sec of air at about 2.43 bar and 356 K This nozzle was combined with two mixing section geometries with throat sizes of 31.8 mm x 203 mm and 47.6 mm x 203 mm and was tested at a total of 11 operating points (Author)

**A76-38482** Use of a spherical concave reflector for jet-noise-source distribution diagnosis W T Chu and R E Kaplan (Southern California, University, Los Angeles, Calif.) *Acoustical Society of America, Journal*, vol 59, June 1976, p 1268 1277 11 refs US Department of Transportation Contracts No OS-00002, No OF-30034

An account on the development of a directional microphone system for jet-noise-source strength distribution measurements is given The system selected is based on the imaging principle of a spherical concave reflector As expected, the system is diffraction limited, a loss of resolution results A special technique is discussed to recover the axial-source strength distribution from the diffracted data Sample experiments are presented to show the successful application of such a system for jet noise measurements (Author)

**A76-38487 \*** Effect of air flow, panel curvature, and internal pressurization on field-incidence transmission loss L R Koval (Missouri, University, Rolla, Mo.) *Acoustical Society of America, Journal*, vol 59, June 1976, p 1379-1385 24 refs Grant No Nsg 1050

In the context of sound transmission through aircraft fuselage panels, equations for the field-incidence transmission loss (TL) of a single-walled panel are derived that include the effects of external air flow, panel curvature, and internal fuselage pressurization Flow is shown to provide a modest increase in TL that is uniform with frequency up to the critical frequency The increase is about 2 dB at Mach number  $M = 0.5$ , and about 3.5 dB at  $M = 1$  Above the critical frequency where TL is damping controlled, the increase can be slightly larger at certain frequencies Curvature is found to stiffen the panel, thereby increasing the TL at low frequencies, but also to introduce a dip at the 'ring frequency' of a full cylinder having the same radius as the panel Pressurization appears to produce a slight decrease in TL throughout the frequency range, and also slightly shifts the dips at the critical frequency and at the ring frequency (Author)

**A76-38492** Cyclic iterative method applied to transonic flow analyses H K Cheng (Southern California, University, Los Angeles, Calif.) and M M Hafez (Flow Research, Inc., Los Angeles, Calif.) In Padé approximants method and its applications to

mechanics Berlin, Springer-Verlag, 1976, p 101-121 22 refs Contract No N00014-67-A-0269-0021

An acceleration technique for transonic aerodynamics computations is discussed, taking into account the basic concepts of the technique and differences of these concepts from the approaches used by Shanks (1955) and Padé (1892) The employment of the new technique in a cyclic iterative procedure is described The implementation of the described approach is illustrated with the aid of a number of examples including a Dirichlet problem and transonic thin airfoil problems G R

**A76-38493 \*** A technique for accelerating iterative convergence in numerical integration, with application in transonic aerodynamics E D Martin (NASA, Ames Research Center, Moffett Field, Calif.) In Padé approximants method and its applications to mechanics Berlin, Springer-Verlag, 1976, p 123-139 22 refs

A technique is described for the efficient numerical solution of nonlinear partial differential equations by rapid iteration In particular, a special approach is described for applying the Aitken acceleration formula (a simple Padé approximant) for accelerating the iterative convergence The method finds the most appropriate successive approximations, which are in a most nearly geometric sequence, for use in the Aitken formula Simple examples are given to illustrate the use of the method The method is then applied to the mixed elliptic-hyperbolic problem of steady, inviscid, transonic flow over an airfoil in a subsonic free stream (Author)

**A76-38552** Metals Society, National Physical Laboratory, and Royal Society, Rosenhain Centenary Conference, London, England, September 22-24, 1975, Proceedings Royal Society (London), *Philosophical Transactions, Series A*, vol 282, no 1307, July 8, 1976 470 p

The present collection of papers deals primarily with materials requirements for specific structures, design implications for materials selection, and present and future development of materials with improved properties Major topics include airframe material requirements, design against brittle fracture, design and materials selection under different types of corrosion, development of line pipe steels, and titanium alloys for engineering structures The future role of physical metallurgy in relation to engineering practice is discussed S D

**A76-38553 #** Airframe material requirements D James (British Aircraft Co., Ltd., Weybridge, Surrey, England) (*Metals Society, National Physical Laboratory, and Royal Society, Rosenhain Centenary Conference, London, England, Sept 22-24, 1975*) *Royal Society (London), Philosophical Transactions, Series A*, vol 282, no 1307, July 8, 1976, p 83-89

This short paper is restricted to a discussion on the characteristics of the principal light alloy materials which have been used in airframe construction over the last few decades In particular, the response of the materials to the operating environment, as shown by problems of fatigue, notch sensitivity and stress corrosion, are discussed These problems have been a major handicap to the achievement of maximum potential structural efficiencies Reference is made to recent developments which offer the prospect of significant improvement The material in the paper is written in general terms and avoids reference to particular specifications, either national or proprietary (Author)

**A76-38554 #** Undercarriage material requirements W M Imrie (Dowty Rotol, Ltd., Gloucester, England) (*Metals Society, National Physical Laboratory, and Royal Society, Rosenhain Centenary Conference, London, England, Sept 22-24, 1975*) *Royal Society (London), Philosophical Transactions, Series A*, vol 282, no 1307, July 8, 1976, p 91-104 38 refs

The main basic engineering requirements for undercarriage materials are described while magnesium, aluminum and titanium



alloys still continue to play a useful part, the ultra high tensile steels are now the preferred choice for many major structural items. The high standard of material quality and subsequent processing control necessary to ensure the integrity of components produced from these steels are described, with specific reference to the 300M alloy. Comparable data on fracture toughness and stress corrosion are given. It is explained why a fracture-mechanics approach to material selection has only limited application and that service reliability is dependent primarily on the steps taken to avoid crack initiation. Despite efforts to improve the intrinsic properties of these steels, with particular emphasis on reducing subcritical crack growth of environmental origin, no worthwhile replacement for 300M has been found. It is concluded that the compromise between strength and brittleness has already been reached. (Author)

**A76-38555 # Gas turbine requirements** R J E Glenney (Royal Aircraft Establishment, Farnborough, Hants, England) and B E Hopkins (Aeronautical Research Council, National Physical Laboratory, Teddington, Middx, England) (*Metals Society, National Physical Laboratory, and Royal Society, Rosenhain Centenary Conference, London, England, Sept 22-24, 1975*) *Royal Society (London), Philosophical Transactions, Series A*, vol 282, no 1307, July 8, 1976, p 105-118 32 refs

The design of gas turbines varies widely according to the requirements of the application and the conditions of service and so, consequently, do the properties necessary in the materials of construction. The main variations on the basic cycle are discussed together with the features that may influence the choice of gas turbine. The importance of the two main operational variables, pressure ratio and turbine entry temperature, is emphasized. Aspects of the design of the main components are considered in relation to the properties required of the materials from which they are made. Higher temperatures and longer lives increase the demands on the metallurgical stability of the materials and their resistance to oxidation and hot corrosion. (Author)

**A76-38563 # Development of Al-Zn-Mg-Cu alloys for aircraft** H Y Hunsicker (Aluminum Company of America, Alcoa Center, Pa) (*Metals Society, National Physical Laboratory, and Royal Society, Rosenhain Centenary Conference, London, England, Sept 22-24, 1975*) *Royal Society (London), Philosophical Transactions, Series A*, vol 282, no 1307, July 8, 1976, p 359-376 62 refs

The paper presents a historical review of the development and application of high-strength Al-Zn-Mg-Cu alloys which have played a key role in making possible the increased size and high reliability of today's commercial aircraft. The early alloys were not adequately resistant to stress corrosion cracking even in the form of thin-section products such as sheet, thin extrusions and tube prevalent in aircraft industry. Considerable advances are achieved in overcoming inadequate stress corrosion cracking and exfoliation corrosion. More closely controlled variants of 7075, i.e., 7175 and 7475, coupled with special manufacturing practices developed within the last 10 years are characterized by higher fracture toughness leading to increasing applications. The newer alloys 7049 and 7050 introduced within the last five years provide further advance in combinations of mechanical properties and environmental resistance resulting in adoption for retrofit programs and inclusion in newly designed aircraft. S D

**A76-38626 Aerodynamic Testing Conference, 9th, Arlington, Tex, June 7-9, 1976, Proceedings** Conference sponsored by the American Institute of Aeronautics and Astronautics. New York, American Institute of Aeronautics and Astronautics, Inc., 1976 304 p. Members, \$20, nonmembers, \$35

Papers are presented on wind tunnel wall interference effects on supercritical airfoils at transonic speeds, blockage effects in a transonic perforated wall wind tunnel, the development of a correctable interference transonic wind tunnel and improvements in the boundary condition of slotted wind tunnel walls. Also examined

are the free-flight investigation of high-maneuverability missile dynamics, measurement of pressure distribution on the surface of spinning wind tunnel models, the investigation of recovery spoilers in hypersonic turbulent flow and rotorcraft aerodynamics and acoustics. Fluctuating disturbances in a Mach-5 wind tunnel, the development of snow erosion test capability for the hyperballistic range, the extrapolation of ground test data to hypersonic reentry conditions and wind tunnel simulation of ablation are also considered.

B J

**A76-38627 \* # Wind tunnel wall interference effects on a supercritical airfoil at transonic speeds** J A Blackwell, Jr and G A Pounds (Lockheed-Georgia Co., Marietta, Ga) In *Aerodynamic Testing Conference, 9th, Arlington, Tex, June 7-9, 1976, Proceedings* New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 1-11 11 refs. Contract No NAS1 12325

Wind tunnel tests of a 10% supercritical airfoil have been conducted in the Lockheed Compressible Flow Facility at transonic speeds to determine the effects of varying wind tunnel wall porosity on airfoil performance. Wall configurations ranging in porosity from 1.3% to 10% were investigated at Reynolds numbers of 7 to 30 million. Experimental data presented to show the effect of varying wall porosity include airfoil surface pressures, airfoil forces, and wind tunnel wall pressures. Utilizing the experimental results, an assessment of the applicability of current subcritical theoretical methods to predict wall interference corrections in subsonic and transonic flows is made. (Author)

**A76-38628 # Analytical methods for determining blockage effects in a perforated wall wind tunnel at transonic speeds** E M Kraft and C F Lo (ARO, Inc., Arnold Engineering Development Center, Arnold Air Force Station, Tenn) In *Aerodynamic Testing Conference, 9th, Arlington, Tex, June 7-9, 1976, Proceedings* New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 12-20 28 refs

Two analytical methods for determining the interference effects of a perforated wind tunnel wall on the flow past a two-dimensional nonlifting airfoil at transonic speeds are presented. The first method approximates the flow field with the linearized transonic small disturbance equation and the interference velocity is determined directly by Fourier transform techniques. This method is readily extended to axisymmetric flows. The second method solves the nonlinear transonic small disturbance equation including shock waves by an integral equation method which is shown to be an order of magnitude more rapid than existing numerical relaxation techniques. It is demonstrated by the integral equation solution that the correct shock location as compared to the free-air solution can be obtained by the proper selection of porosity. However, this optimum porosity is shown to be dependent on the Mach number and the airfoil configuration. (Author)

**A76-38629 \* # Improvements in the slotted-wall boundary condition** R W Barnwell (NASA, Langley Research Center, Subsonic-Transonic Aerodynamics Div., Hampton, Va) In *Aerodynamic Testing Conference, 9th, Arlington, Tex, June 7-9, 1976, Proceedings* New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 21-30 7 refs

It is shown that the form of the slotted wind tunnel wall boundary condition can be obtained directly from the ideal slot conditions without specification of the cross-sectional geometry of the slot. The treatment of flat slots is generalized so that configurations with sidewalls in the plenum can be treated. It is shown that these variations do not change the slotted-wall boundary condition significantly. It is concluded that the effects of slot sidewalls and separation in the plenum on the coefficient of the slotted-wall boundary condition are small compared to the effect of the slot on the tunnel side. B J

**A76-38630 \* # Toward the correctable-interference transonic wind tunnel** W B Kemp, Jr (NASA, Langley Research Center,

Subsonic Transonic Aerodynamics Div , Hampton, Va ) In Aero dynamic Testing Conference, 9th, Arlington, Tex , June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc , 1976, p 31-38 12 refs

The concept of a correctable-interference transonic wind tunnel combining a capability for wall interference assessment with a limited capability for wall control is introduced Recent progress toward achieving the interference assessment capability is described The feasibility of using experimentally measured data directly as boundary values for the assessment in lieu of more generally formulated but less accurate wall boundary conditions is demonstrated for two-dimensional subsonic flows Also, a procedure for transonic analysis of wall interference which leads to a rational definition of the wall-induced perturbation field within the context of nonlinear transonic flow computations is outlined in principle

(Author)

**A76-38631 # Transonic testing of a self optimizing flexible airfoil** E S Levinsky, R H Schappelle, and S Pountney (General Dynamics Corp , Convair Div , San Diego, Calif ) In Aerodynamic Testing Conference, 9th, Arlington, Tex , June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc , 1976, p 39-49 16 refs Navy-supported research

An interactive airfoil optimization technique has been demonstrated in a 2 D blow-down tunnel using a 10% thick flexible airfoil model with hydraulic actuators designed to independently vary leading edge radius, leading edge incidence, lower surface humping, aft camber and trailing edge deflection while the tunnel was running A link-up of three analog and digital computers analyzed the test data 'on line' and controlled airfoil shape and angle of attack to minimize drag, subject to constraints on lift and trailing edge pressure, using the gradient projection optimization algorithm Satisfactory convergence was found at freestream  $M = 0.75$ , even with flow separation

(Author)

**A76-38632 \* # Gamma-effects on 2-dimensional transonic aerodynamics** K Tuzla, D A Russell (Washington, University, Seattle, Wash ), and J C Wai In Aerodynamic Testing Conference, 9th, Arlington, Tex , June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc , 1976, p 50-58 14 refs Grant No NGR-48-002-107

Nonlifting 10% biconvex airfoils are mounted in a 30 x 40 cm Ludwig-tube-driven transonic test-section and the flow field recorded with a holographic interferometer Nitrogen, argon, and carbon dioxide are used as the principal test gases Experiments are conducted with Reynolds number based on chord of (0.5-3.5) x 10 to the 6th with Mach numbers of 0.70, 0.75, and 0.80 Supporting calculations use inviscid transonic small-disturbance and full-potential computer codes coupled with simple integral boundary-layer modeling Systematic studies show that significant gamma-effects can occur due to shock-induced separation

(Author)

**A76-38639 # Computer controlled system for the investigation of the flow behind a sweptback wing** Z M El-Ramly and W J Rainbird (Carleton University, Ottawa, Canada) In Aerodynamic Testing Conference, 9th, Arlington, Tex , June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc , 1976, p 119-128 17 refs Research supported by the Lockheed-Georgia Co , National Research Council of Canada Grant No A-7799

A completely computer controlled wind tunnel test facility designed for measurements of the vortical flow field behind a lifting swept-back wing is described The vortex generator model is a pressure plotted root mounted half-wing To avoid unrepresentative end effects, distributed wing root suction is applied over an area surrounding the root chord The detailed design and calibration of the root suction system is discussed Flow field measurements were made using a pre-calibrated non-nulling blunted conical 5-hole probe

The use of the conical head made probe calibration, over a wide flow angle range, and the consequent memory required to store the calibration data, a simple task The program developed can calculate and plot, on line, the three components of velocity and vorticity, the total pressure loss coefficient and the circulation distribution

(Author)

**A76-38641 \* # A general rotor model system for wind-tunnel investigation of rotorcraft aerodynamics and acoustics** J C Wilson (NASA, Langley Research Center, U S Army, Air Mobility Research and Development Laboratory, Hampton, Va ) In Aerodynamic Testing Conference, 9th, Arlington, Tex , June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc , 1976, p 136-142 8 refs

A complex rotorcraft model system has been developed by the NASA Langley Research Center and the U S Army Air Mobility R&D Laboratory, Langley Directorate, for aerodynamic and acoustic experimental investigations in the NASA Langley V/STOL tunnel This generalized rotor model system has a powered main rotor, tail rotor, and auxiliary engine capability It may be configured to represent a variety of rotorcraft configurations The first investigation was conducted to determine the performance, acoustic, stability and control characteristics of the NASA/Army Rotor Systems Research Aircraft with an articulated rotor In a second investigation, a quarter-scale AH-1G configuration with a teetering rotor is being represented to determine if a V-tail will improve the directional characteristics Future programs are planned to investigate advanced rotor blade airfoils for improved performance and acoustic characteristics

(Author)

**A76-38642 \* # Wind-tunnel testing with a rotary-balance apparatus to simulate aircraft spin motions** G N Malcolm (NASA, Ames Research Center, Moffett Field, Calif ) and M H Clarkson (NASA, Ames Research Center, Moffett Field, Calif , Florida, University, Gainesville, Fla ) In Aerodynamic Testing Conference, 9th, Arlington, Tex , June 7-9, 1976, Proceedings

New York, American Institute of Aeronautics and Astronautics, Inc , 1976, p 143-156 6 refs

Experiments have been conducted in the Ames 12-Foot Pressure Wind Tunnel on a simple airplane-like model using a rotary-balance apparatus to simulate a steady spin motion at high angles of attack Tests were run at Mach numbers of 0.1 and 0.25 over a wide Reynolds number range with the angle of attack varying from 45 to 90 deg During previous tests of the same research model, some difficulties were experienced with measurement accuracy in the low-to-medium range of Reynolds number because of limitations in the sensitivity of selected force balances For the present tests, special balances were built to provide accurate measurements of the nose and tail contributions to spin motions and improvements were made to the overall test apparatus The results of this test, including some interesting hysteresis effects with spin rate, are described Some of the problems associated with rotary balance tests at high Reynolds numbers are discussed A new large-scale rotary apparatus now nearing completion for use in the Ames 12-Foot and 11 by 11-Foot Wind Tunnels is described briefly

(Author)

**A76-38650 # A new facility for mass flow calibration and static inlet testing** D N Kendall and R C Crites (McDonnell Aerodynamics and Propulsion Laboratories, St Louis, Mo ) In Aerodynamic Testing Conference, 9th, Arlington, Tex , June 7-9, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc , 1976, p 238-245

This paper reports the design, installation, and utilization of a new ground test facility, the Mass Flow Calibration Facility (MFCF), for the determination of static performance of aircraft inlet models and for the calibration of associated airflow metering devices such as mass flow plugs, venturis, bleeds, etc Design constraints for this new facility required that controlled airflow rates range from 0.03 to 110

lb-m/sec with an uncertainty not to exceed 0.5 percent of reading. A geometrically similar family of critical flow venturis was designed and fabricated for the measurement of mass flow rate. A closed loop control system incorporating a minicomputer consolidates gas dynamic and thermodynamic properties, venturi coefficients, and precision pressure and temperature measurements needed to compute actual flow rate. The minicomputer computes and compares the actual flow rate to the desired flow rate and commands a twenty four element digital control valve to obtain the desired flow rate. Shakedown tests and calibration programs have shown that the MFCE is performing well within its design objectives. (Author)

**A76-38651 # Applications of flow diagnostic techniques to aerodynamic problem solving** D. George-Falvy (Boeing Commercial Airplane Co., Seattle, Wash.) In *Aerodynamic Testing Conference*, 9th, Arlington, Tex., June 7-9, 1976, Proceedings. New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 246-260.

The objective of this paper is to illustrate the role of flow diagnostic techniques in aerodynamic troubleshooting work. Several Boeing test programs are discussed in which flow diagnostic measurements provided substantial aid in solving difficult aerodynamic problems. The selected examples are concerned with the evaluation and improvement of engine nacelle installations on subsonic transport airplanes. Included are (1) flow diagnostic flight tests on the engine-nacelle of the Boeing 747 and development of a drag reducing fillet fairing, (2) improvement of the Boeing 707 quiet nacelle design, and (3) exploratory wind tunnel tests of high-bypass ratio engine installations for the Boeing 727. Special testing techniques and test equipment are described and correlations between flight and wind tunnel test data are shown. (Author)

**A76-38656 # Comparison of wind tunnel and flight test heat-transfer measurements on a pylon-mounted store.** R. K. Matthews (ARO, Inc., von Karman Gas Dynamics Facility, Arnold Air Force Station, Tenn.) and J. C. Key, Jr. (USAF, Armament Development Laboratory, Eglin AFB, Fla.) In *Aerodynamic Testing Conference*, 9th, Arlington, Tex., June 7-9, 1976, Proceedings. New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 288-291. 7 refs. USAF-sponsored research.

Flight and wind tunnel heat-transfer measurements were carried out on a pylon-mounted store for bomb dummy units on an F-111 aircraft. To investigate the significant parameters and to guide experimental work, the Spalding-Chi (1964) turbulent heating method was employed. Flight test data were obtained during constant altitude and Mach number flights at a free stream Mach number of 2. The 1/15-scale wind tunnel tests were performed in a 40 x 40 in. tunnel. These tests aimed at substantiating wind tunnel to flight extrapolation procedures. Scatter in the flight test data hindered any definite conclusion. There is some evidence to substantiate the underlying correlation parameter, however, better quality flight data are needed. S D

**A76-38657 # A multifaceted store separation analysis** H. R. Spahr, R. N. Everett, and J. K. Kryvoruka (Sandia Laboratories, Albuquerque, N. Mex.; Sandia Laboratories, Livermore, Calif.) In *Aerodynamic Testing Conference*, 9th, Arlington, Tex., June 7-9, 1976, Proceedings. New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 292-300. 15 refs. ERDA supported research.

Theoretical analysis, wind tunnel captive trajectory simulation, a simplified grid simulation, and full-scale flight drop tests have been used in a unified multifaceted store separation analysis for two stores with small aerodynamic static margins released from two different aircraft. The relative advantages and disadvantages of each method are defined. For the first time in the literature, direct comparisons are presented between the results obtained using all four methods. Good agreement is shown in the comparisons. Such comparisons are

needed to define the accuracy with which each of the other store separation analysis methods reproduce the results of fully-instrumented full-scale flight drop tests. (Author)

**A76-38851 # The supersonic challenge (El desafío supersónico)** A. Rodríguez-Carmona (Iberia, S.A., Madrid, Spain). *IAA/Ingeniería Aeronáutica y Astronáutica*, vol. 28, May 1976, p. 7-18. In Spanish.

The post-World War II history of commercial jet-propulsion craft is reviewed with emphasis on competing designs and competition between American and West European industries. The American SST program, the Soviet supersonic jet program, and the Anglo-French Concorde project are reviewed and compared, with economic problems and public acceptance problems (noise levels, environmental impact, economic necessity) taken into account. Future supersonic commercial developments are adumbrated, with emphasis placed on development of a new engine type meeting requirements for take-off and supersonic flight. The effects of the worldwide recession of the early 70s and the mid 70s fuel crisis are mentioned. The 1980-1985 period is projected as one to witness development and acceptance of supersonic commercial flight on a broad scale. R D V

**A76-38852 # The CFM 56 - A novel concept in industrial cooperation (CFM 56 - Un nuevo concepto de cooperación industrial)** A. de Benito. *IAA/Ingeniería Aeronáutica y Astronáutica*, vol. 28, May 1976, p. 19-24. In Spanish.

The way in which the CFM international corporation is organized and financed is discussed along with some details of the CFM turbofan engine (fan, compressor stages, oil lubrication system, modular system). Certification and testing programs are outlined, including hours logged in flight and on test stand, and security measures for the core of the engine (identical to the F101). The CFM 56 engine is not linked to any particular aircraft project, but is meant to fill a gap in the world market. Test data are satellite-transmitted computer-to-computer (Villaroche to Evendale, Ohio, USA). Relations of General Electric and Snecma to the CFM corporation are indicated. R D V

**A76-38853 # Aircraft design engineering (La técnica de proyecto de aeronaves)** J. L. Lopez Ruiz (Construcciones Aeronáuticas, S.A., Madrid, Spain). *IAA/Ingeniería Aeronáutica y Astronáutica*, vol. 28, May 1976, p. 25-30. In Spanish.

A status report on the C-101 Spanish-designed aircraft with emphasis on conditions facing aerodynamic and production design in a moderately developed country such as Spain. A typical design sequence and hierarchy is presented and motivated. Early amateur conducted design work in Spain, benefits to Spanish aircraft design capabilities from association with advanced German design cadres and know-how in the '40s, the slump due to post-war isolation, and a resurgence starting in the late '50s with American support are reviewed historically. The C-101 program is currently at initial testing and construction of models and mockups, at least a year away from flight testing, and some design work is farmed out to West German and US associates because of Spain's lack of facilities for high speed structural and air intake testing or adequate wind tunnels. R D V

**A76-38903 # Flights at supersonic speeds in civil air traffic - Comments concerning the change in the air traffic regulations for the Federal Republic of Germany /BR-Publication 469/75/ (Flüge mit Überschallgeschwindigkeit im Zivilluftverkehr - Zur Änderung der Luftverkehrs-Ordnung der Bundesrepublik Deutschland /BR-Drucks 469/75/)** H. Achtnich (Arbeitsgemeinschaft Deutscher Verkehrsflughäfen, Stuttgart, West Germany). In *Contributions to air and space law*. Publication in honor of Alex Meyer. Cologne, Carl Heymanns Verlag, 1975, p. 3-11. 34 refs. In German.

A proposal for a change of the air traffic regulations in West Germany has been submitted to the Federal Council on July 24,

1975 A basic statute in the proposed regulations prohibits flights of civil aircraft at supersonic speeds (greater than Mach 1) The new regulations try to protect the population of West Germany against adverse sonic-boom effects related to the flight of aircraft at supersonic speeds Supersonic aircraft that do not produce sonic booms which can be noticed at ground locations are to be admitted  
G R

**A76-39005** Low-frequency approximations in unsteady small perturbation subsonic flows R K Amiet (United Technologies Research Center, East Hartford, Conn) *Journal of Fluid Mechanics*, vol 75, June 11, 1976, p 545-552 16 refs

The Prandtl-Glauert rule for small perturbation subsonic flow with a time-dependent boundary condition, as in the case of an oscillating airfoil, is extended to include the first order term in the oscillation frequency The technique involves application of Galilean and Lorentz transformations to reduce the convective wave equation to the standard wave equation for zero mean flow The method is applied to the examination of two- and three-dimensional cases with and without shed vorticity  
B J

**A76-39006** The generation of sound by two-phase nozzle flows and its relevance to excess noise of jet engines O J Whitfield and M S Howe (Cambridge University, Cambridge, England) *Journal of Fluid Mechanics*, vol 75, June 11, 1976, p 553-576 31 refs

An experiment using a water jet containing flow inhomogeneities in the form of air or helium bubbles exhausting through a conical nozzle or a specially contoured 'bellmouth' nozzle is performed to determine whether the 'excess' noise of a jet issuing from a conical nozzle can be significantly reduced by reducing the maximum pressure gradient in the flow It is shown that the level of internally generated noise is controlled by the mean-flow pressure gradient and use of the bellmouth nozzle leads to substantial noise reduction It is found that there is an absolute difference in the sound pressure levels produced when helium rather than air bubbles are used under otherwise identical flow conditions  
B J

**A76-39092** Wrought aluminium alloys as materials for structural components subject to dynamic stresses (Aluminium-Knetlegierungen als Konstruktionswerkstoffe für schwingbeanspruchte Bauteile) E Gassner, C-L Matschke, and H Ostermann (Laboratorium für Betriebsfestigkeit, Darmstadt, Fraunhofer Gesellschaft, Gemeinnütziges Forschungsinstitut, Linden, West Germany) In International Conference on Light Metals, 6th, Leoben and Vienna, Austria, June 16-20, 1975, Proceedings Dusseldorf, Aluminium-Verlag GmbH, 1975, p 87-90 6 refs In German

Starting with the most important structural alloys and their dynamic strength the author discusses the question to what extent these material characteristics can be maintained in constructions with a high load factor Examples illustrate how, where local stress concentrations cannot be avoided, service strength and service life can be substantially increased by modern design concepts and measures affecting production (Author)

**A76-39100** Production of drop forgings from high-strength aluminum alloys with reference to residual stress problems (Die Herstellung von Gesenkschmiedestücken aus hochfesten Aluminiumlegierungen unter Berücksichtigung der Eigenspannungsprobleme) G Fischer and D Sauer (Otto Fuchs Metallwerke, Meinerzhagen, West Germany) In International Conference on Light Metals, 6th, Leoben and Vienna, Austria, June 16-20, 1975, Proceedings Dusseldorf, Aluminium-Verlag GmbH, 1975, p 240-242 8 refs In German

The paper sets forth the steps in the production of drop-forged aluminum aviation components, describing in particular those mea-

sures taken to ensure optimal fiber structure and high strength of the piece A special pre-drop step is shown to yield better fiber structure, conforming to the shape of the required component It is frequently necessary to carry out a solution heat treatment of a forged aluminum piece with subsequent quenching in cold water This induces certain residual stresses, which in pieces of simple geometry can be removed by cold deformation For pieces of more complicated geometry, it appears best to resort to using alloys for which cooling from the solution heat treatment temperature can proceed slowly Replacement of chromium by zirconium in a number of aluminum alloys has proven successful Drop forgings of this type and their properties are described  
P T H

**A76-39106** Applications of beryllium and alloys of titanium and magnesium in aeronautical and space structures (Applications du beryllium et des alliages de titane et de magnésium dans les constructions aeronautiques et spatiales) G Sertour, J Blondel, M Armbruster, and A Bourgeois (Société Nationale Industrielle Aérospatiale, Suresnes, Hauts-de-Seine, France) In International Conference on Light Metals, 6th, Leoben and Vienna, Austria, June 16-20, 1975, Proceedings Dusseldorf, Aluminium Verlag GmbH, 1975, p 271-273 In French

The paper summarizes some of the main physical characteristics of beryllium and alloys of magnesium and titanium and identifies with brief descriptions some typical applications of these materials in aviation and space technology The greatest problem with beryllium is its oxidability, while difficulties in producing semifinished material increase its cost Use of magnesium is generally restricted to pieces of complicated geometry where the risk of corrosion is slight The properties of titanium are such that it can replace steel in many areas of aircraft structure, but the cost of titanium has limited its use  
P T H

**A76-39107** Manufacturing and service experience of the use of titanium and magnesium in aircraft and missiles A Kleivan (Saab-Scania AB, Linköping, Sweden) In International Conference on Light Metals, 6th, Leoben and Vienna, Austria, June 16-20, 1975, Proceedings Dusseldorf, Aluminium-Verlag GmbH, 1975, p 274-276

Experience in producing various aircraft structural components out of titanium and magnesium is related The titanium parts were made by forging, extrusion, and hot forming of sheets Some cases called for welding of assemblies Magnesium parts were sand-cast Careful attention is given to reasons for rejection of pieces before and after installation on the aircraft  
P T H

**A76-39108** Titanium structures in commercial subsonic aircraft R J H Wanhill (Nationaal Luchtvaartlaboratorium, Amsterdam, Netherlands) In International Conference on Light Metals, 6th, Leoben and Vienna, Austria, June 16-20, 1975, Proceedings Dusseldorf, Aluminium-Verlag GmbH, 1975, p 279-281 31 refs

The paper studies the problem of cost-weight tradeoffs involved in projected use of titanium for the primary airframe of future subsonic aircraft Basically, the problem can be formulated in terms of how much weight must be saved in order to recoup losses due to the extra cost of titanium as compared to aluminum, but simple calculations show that nearly 40% of the weight of a low cost aircraft must be saved, which is impossible In sophisticated aircraft, 10-15% weight must be saved, which is also very demanding Study of weight saving potential offered by various advanced panel concepts shows that weight savings of 25-35% can be achieved with composite-reinforced concepts and aluminum-brazed titanium honeycomb Composite-reinforced titanium gives superlative fatigue strength and fatigue crack propagation resistance, in part because of the closely matched thermal expansion coefficients of titanium and boron-epoxy All-metal concepts achieve weight savings of 15-25%, there being no essential superiority of titanium over aluminum  
P T H

**A76-39178** Technological constraints on the aerodynamic design of fluid flow engines (Contraintes technologiques de l'étude

aerodynamique des turbomachines) J-P Guyot (SNECMA, Paris, France) (*Société Française des Mécaniciens and Fédération des Industries Mécaniques et Transformatrices des Métaux, Conférence sur l'Aérodynamique Interne de Turbomachines, Paris, France, Dec 12, 13, 1974*) *Revue Française de Mécanique*, 3rd and 4th Quarter, 1975, p 5-17 In French

The major design objectives for fluid flow engines are outlined. The role of 'technological constraints' strength, vibrational behavior, dismountability, fabrication, cyclic fatigue - in the evolution of an engine design with optimum aerodynamic characteristics is examined. The effect of these technological constraints on the aerodynamic design of the secondary rectifier, fan, and high and low-pressure compressors of modern civil aircraft engines is discussed in detail. C K D

**A76-39179** Dissipative phenomena in axial fluid flow engines (Phénomènes dissipatifs dans les turbomachines axiales) J Mathieu (Lyon I, Université, Lyons, France) (*Société Française des Mécaniciens and Fédération des Industries Mécaniques et Transformatrices des Métaux, Conférence sur l'Aérodynamique Interne de Turbomachines, Paris, France, Dec 12, 13, 1974*) *Revue Française de Mécanique*, 3rd and 4th Quarter, 1975, p 31-42 24 refs In French

Dissipative phenomena arising from turbulence in axial fluid flow engines are analyzed. Two dimensional models used to analyze viscous flow over the turbine blades are outlined, and their shortcomings are discussed. The theoretical treatment of heat transfer is considered. The equations developed by Bradshaw (1971) form a base for an examination of possible approaches to the evolution of a useful three-dimensional boundary layer model. C K D

**A76-39180** Fundamental aspects of turbine blade cooling (Refroidissement des aubes de turbine aspects fondamentaux) E Le Grives (ONERA, Châtillon sous Bagneux, Hauts-de-Seine, France) (*Société Française des Mécaniciens and Fédération des Industries Mécaniques et Transformatrices des Métaux, Conférence sur l'Aérodynamique Interne de Turbomachines, Paris, France, Dec 12, 13, 1974*) *Revue Française de Mécanique*, 3rd and 4th Quarter, 1975, p 43-53 22 refs In French. Research supported by the Direction des Recherches et Moyens d'Essais

The process of temperature evolution and the distribution of thermal stresses in high temperature turbine engines are examined to indicate cooling requirements. Theoretical and technological characteristics of cooling techniques using air from the compressor, including internal convection, impact cooling, film cooling with injection through several rows of holes, and full coverage film cooling, are discussed. The effectiveness of film cooling is assessed, and attention is given to the overall energy balance between external and internal convection in full coverage film cooling. Experimental studies of systems using liquid metal coolant in either a thermosiphon or evaporative cycle are described, and the effect of air cooling on the aerodynamic performance of the turbine is considered. C K D

**A76-39181** Fundamental aspects of the aerodynamics of turbojet engine combustors (Aérodynamique des chambres de combustion de turboréacteur aspects fondamentaux) M Barrère (ONERA, Châtillon-sous-Bagneux, Hauts-de-Seine, France) (*Société Française des Mécaniciens and Fédération des Industries Mécaniques et Transformatrices des Métaux, Conférence sur l'Aérodynamique Interne de Turbomachines, Paris, France, Dec 12, 13, 1974*) *Revue Française de Mécanique*, 3rd and 4th Quarter, 1975, p 55-68 9 refs In French. Research supported by the Direction des Recherches et Moyens d'Essais

Aerodynamic considerations in the design of high-performance combustors for turbojet engines are discussed. Aerodynamic problems concerning the preparation of the fuel-air mixture, the recirculation zone where primary combustion occurs, the secondary combustion zone, and the dilution zone are examined. An aerodynamic analysis of the entire primary chamber ensemble is carried out to determine the pressure drop between entry and exit. The

aerodynamics of afterburn chambers are discussed. A model which can be used to investigate the evolution of temperature, pressure, and rate and efficiency of combustion the length of the chamber is developed. C K D

**A76-39182** Practical applications of combustion chamber aerodynamics (Aérodynamique des chambres de combustion applications pratiques) J Caruel (SNECMA, Paris, France) (*Société Française des Mécaniciens and Fédération des Industries Mécaniques et Transformatrices des Métaux, Conférence sur l'Aérodynamique Interne de Turbomachines, Paris, France, Dec 12, 13, 1974*) *Revue Française de Mécanique*, 3rd and 4th Quarter, 1975, p 69-76 In French

Practical application of basic aerodynamic principles in the optimization of combustion chambers for gas turbine engines is discussed. The advantages and limitations of annular chambers relative to tubular and tubo-annular chambers are considered. The optimization of air flows in the primary and dilution zones and upstream of the flame tube is examined, with special attention given to techniques and approaches used by SNECMA in engine design. The aerodynamics of wall cooling by an air film is outlined, and the double expansion system developed by SNECMA is described. C K D

**A76-39193** Some UK-government establishment research towards quieter aircraft. F W Armstrong (National Gas Turbine Establishment, Farnborough, Hants, England) and J Williams (Royal Aircraft Establishment, Farnborough, Hants, England) *Journal of Sound and Vibration*, vol 47, July 22, 1976, p 207-236 25 refs

The paper describes the development of experimental facilities at the National Gas Turbine Establishment and the Royal Aircraft Establishment, directed towards the evolution of cost effective quieter aircraft. Attention is paid to the following aspects of quiet aircraft research: engine exhaust noise research, the use of absorber liners in engines, the development of noise testing facilities including flight simulation, and research on airframe effects such as noise-shielding and self noise. Multivariable design synthesis involving flexible matching of engine and airframe design parameters, with the aim of achieving a better balance of aircraft noise, performance and economic characteristics, is described. B J

**A76-39198** The stability of the Laval shaft with internal and external damping, taking into account the gyroscopic effect of the rotor mass (Zur Stabilität der Laval-Welle mit innerer und äußerer Dämpfung unter Berücksichtigung der Kreiselwirkung der Rotormasse) H Pfutzner (Berlin, Technische Universität, Berlin, West Germany) *Forschung im Ingenieurwesen*, vol 42, no 4, 1976, p 130-135 6 refs In German

Internal damping effects in the case of rotating shafts can produce flexural vibrations. Instability phenomena have been observed if the speed of rotating Laval shafts without gyroscopic effects exceeds a certain value. The rotational speed limit for stable operation increases or decreases if the gyroscopic effect of the rotor mass is taken into consideration. An approach is described for the determination of this rotational speed limit as a function of all significant system parameters. G R

**A76-39204 #** Aircraft structural stability. Methods for normalizing design restriction on aircraft structural stability (Prochnost' samoleta. Metody normirovaniya raschetnykh uslovii prochnosti samoleta) A I Makarevskii, N N Korchemkin, T A Frantsuz, and V M Chizhov. Moscow, Izdatel'stvo Mashinostroenie, 1975 280 p 17 refs In Russian

The book sets forth methods for calculating external loads on aircraft structures under a wide range of flight conditions, incorporating conventional and probabilistic methods of calculating dynamic loads of elastic structures. Attention is given to maneuvering overloads, loads arising during flight in agitated air, distribution

of aerodynamic loads, tail assembly loading, loads on the under carriage during take off and landing, dynamic effect of loads during flight in agitated air, simulation of flight in agitated air in wind tunnels, dynamic effect of loads during landing of heavy aircraft, principles of probabilistic statistical methods for determining load norms, statistical analysis of external loads, analysis of statistical data on excessive loads leading to failure, and selection of safety factors

P T H

**A76-39218**      **Synthesis of subsonic airplane design** E Torenbeek (Delft, Technische Hogeschool, Delft, Netherlands) Delft, Delft University Press, 1976 618 p 1130 refs \$27 80

General aspects of aircraft configuration development are considered along with the general arrangement of a new aircraft design, fuselage design, aspects of subsonic engine technology, effects of mission and flight performance characteristics, the choice of the engine and the propeller, the installation of the powerplant, aspects of wing design, aircraft weight and balance, and preliminary tailplane design. Attention is also given to the undercarriage layout, an analysis of aerodynamic and operational characteristics, the evaluation and presentation of a preliminary design, definitions relating to the geometry and aerodynamic characteristics of airfoils, a prediction of wing structural weight, the weight penalty method for fuselage structural weight prediction, and the prediction of lift and drag in the low-speed configuration

G R

**A76-39219**      **Design to Cost Conference, Newport Beach, Calif., December 1, 2, 1975 and Arlington, Va., February 9, 10, 1976, Abridged Proceedings** Conference sponsored by the American Institute of Aeronautics and Astronautics Los Angeles, American Institute of Aeronautics and Astronautics, Inc., 1976 116 p

Summaries are presented of ten papers reviewing the state of the art of design-to-cost methods and discussing the application of these methods to particular projects. The design-to-cost objectives of the Department of Defense are outlined. Individual topics include the implementation of the design-to-cost programs for the APN-209 absolute altimeter, the XM-1 tank, the F-15, the advanced medium STOL transport, and the guided missile frigates FFG 7 ship acquisition program. The management of life cycle costs in the Department of Defense is also treated

C K D

**A76-39429** #      **Model-following in linear-quadratic optimization** E Kreindler (Technion - Israel Institute of Technology, Haifa, Israel) and D Rothschild (Grumman Aerospace Corp., Bethpage, N.Y.) *AIAA Journal*, vol 14, July 1976, p 835-842 16 refs

The use of models (linear differential equations embodying the desired properties) in the design of linear feedback systems via linear-quadratic optimization is treated. Two methods are discussed and compared on a numerical, lateral-axis aircraft control application: explicit model following, which entails the simulation of the model as part of the feedforward controller, and implicit model-following, where the model serves to define the performance index. By and large, the implicit model method is found to be superior over explicit model-following. For implicit model-following, it is shown that (1) a cross-product term introduced into the performance index vanishes for several classes of systems, including those of flight control, (2) one part of the control-law matrix  $K$  minimizes the integrand of the performance index and dominates  $K$  as the weight of the states in the index is increased, and (3) every desired linear control law can be obtained via optimal implicit model-following by a suitably defined model

(Author)

**A76-39430** \* #      **Solution of the minimum time-to-climb problem by matched asymptotic expansions** M D Ardema (NASA, Ames Research Center, Research Aircraft Technology Office, Moffett Field, Calif.) *AIAA Journal*, vol 14, July 1976, p 843-850 20 refs

Application of singular perturbation techniques to trajectory

optimization problems of flight mechanics is discussed. The method of matched asymptotic expansions is used to obtain an approximate solution to the aircraft minimum time to climb problem. Outer, boundary-layer, and composite solutions are obtained to zeroth and first orders. A stability criterion is derived for the zeroth-order boundary-layer solutions (the theory requires a form of boundary-layer stability). A numerical example is considered for which it is shown that the stability criterion is satisfied and a useful numerical solution is obtained. The zeroth order solution proves to be a poor approximation, but the first order solution gives a good approximation for both the trajectory and the minimum time to climb. The computational cost of the singular perturbation solution is considerably less than that of a steepest descent solution. Thus singular perturbation methods appear to be promising for the solution of optimal control problems

(Author)

**A76-39433** #      **Aerodynamics of slender rolling wings at incidence in separated flow** M J Cohen and D Nimri (Technion - Israel Institute of Technology, Haifa, Israel) *AIAA Journal*, vol 14, July 1976, p 886-893 12 refs

A solution to the problem of slender wings in roll about the wind axis and at angle of attack is presented. The basic approach used is a variation of that of Brown and Michael (1955) interpreted to take into account the antisymmetrical component in the resultant flow. A pressure distribution function is derived and plotted in a representative range of the key parameters (rate of roll of the wing about the wind axis, nondimensional angle of attack of the wing, nondimensional semispan), and a general expression for the evaluation of the damping contribution in roll caused by leading-edge separation in slender wings is given. The method is applied here for the evaluation of the roll damping moment and pitch coupling of a basic delta wing, but the pressure distribution function is given in generalized form. This should enable the flow characteristics on more general rolling configurations to be reliably assessed within the limitation of the model adopted

(Author)

**A76-39434** \* #      **Time development of the flow about an impulsively started cylinder** F D Deffenbaugh (TRW Systems, Redondo Beach, Calif.) and F J Marshall (Purdue University, West Lafayette, Ind.) *AIAA Journal*, vol 14, July 1976, p 908-913 21 refs Grant No. NGR 15 005-119

A method is developed to determine the time dependent flowfield about an impulsively started circular cylinder. An outer potential flow model is interfaced with an inner viscous flow region. The wake is described by a set of elementary point vortices. The position at which the point vortices are shed from the cylinder is obtained from a solution to the unsteady incompressible laminar boundary layer equations. A rear shear layer is postulated to account for backflow induced vorticity. Wake development is detailed from the initial formation of the two symmetric vortices to subsequent asymmetry and eventual alternate shedding. Unsteady pressure distributions, lift and drag forces, and Strouhal number are calculated and compared with experiment

(Author)

**A76-39525** #      **Optimization of aircraft flight regimes. Economical flight regimes (Optimizatsiya rezhimov poleta samoleta. Ekonomicheskie rezhimy poleta)** S Iu Skripnichenko (Moscow, Izdatel'stvo Mashinostroenie, 1975 192 p 39 refs. In Russian)

The book deals with cost analysis of transport aircraft flight and studies methods of calculating optimal flight regimes according to economic criteria and an energy approach. Operational constraints on flight paths and their influence on the flight regimes of subsonic and supersonic aircraft are examined. Fundamental economic indices are defined and discussed, and their dependence on time of flight and fuel consumption is traced. Systems of equations are introduced for determining optimal regimes of cruising flight, altitude climb, and descent according to criteria of minimal transport costs with allowance for the mutual influence of the different flight stages. A method is studied for determining the optimal flight plan with consideration for the meteorological conditions on the path

P T H

**A76-39571** The user's point of view on operational aspects of Concorde (Point de vue de l'exploitant sur les aspects opérationnels de Concorde) P Dudal (Compagnie Nationale Air France, Division Concorde, Paris, France) *L'Aéronautique et l'Astronautique*, no 58, 1976, p 3-8 In French

The handling and maneuverability of Concorde are discussed, and its flight regime is compared with those of subsonic commercial transports. Special attention is given to constraints imposed by the delta wing at low speeds and to measures taken to minimize fuel consumption and noise problems in crossing the sound barrier. Centering control is described, and medico-physiological effects of high-altitude supersonic flight are briefly considered. C K D

**A76-39572** The aviation engine industry (L'industrie des moteurs aéronautiques) A Bodemer (SNECMA, Moissy Cramayel, Seine-et-Marne, France) *L'Aéronautique et l'Astronautique*, no 58, 1976, p 27-43 In French

A detailed review of the organization and affiliations of the major Western aircraft engine producers is presented. The European companies included in the discussion are Rolls Royce, SNECMA, Turbomeca, Motoren und Turbinen Union, Volvo-Flygmotor, Fiat, and Fabrique Nationale. American firms included are Pratt and Whitney, General Electric, Garrett-Air Research, Avco-Lycoming, and Detroit Diesel-Allison. The major military and civil engine development programs under way or proposed by these companies are outlined, and brief descriptions of the principal design features of the engines involved are provided. C K D

**A76-39573** New European helicopters (Nouveaux hélicoptères européens) G Bruner (Centre de Documentation de l'Armement, Paris, France) *L'Aéronautique et l'Astronautique*, no 58, 1976, p 45-61 5 refs In French

A review of European civil and military helicopters recently introduced or in design and development stages is presented. Included are aircraft based on new design concepts or derived from earlier models. The design and performance characteristics of the Aerospatiale Super Frelon SA 321 G, Lama SA 315 B, Dauphin SA 360 C and SA 365, Aerospatiale/Westland Gazelle SA 342, Puma SA 330 and Lynx WG 13, Westland Sea King, Agusta Bell AB 206 B and AB 212, Agusta A 109 and A 129, MBB BO 105, and Kamov KA 26 are given. C K D

**A76-39596** Putting a value on noise E J Richards (Southampton, University, Southampton, England) (*Royal Aeronautical Society, Lecture, Henlow, England, Feb 18, 1976*) *Aeronautical Journal*, vol 80, May 1976, p 193-204 18 refs. Research sponsored by the Civil Aviation Authority

Different approaches to the problem of assessing the value of damages to communities surrounding an airport due to high noise levels are considered. The derivation and application of the most widely used noise indices, including Perceived Noise Level (PNdB), Community Noise Rating (CNR), and the Noise and Number Index (NNI), are discussed. Different concepts which have been used in the past to delineate the rights of individuals in an industrial society (the equality notion, the classical utilitarian notion, the Pareto optimality criterion, the Hicks-Kaldor principle, the Rawls notion) are outlined, and their implications when applied to the assessment of damages arising from aircraft noise are examined. It is argued that the estimation of dis-amenity and benefit in monetary terms is likely to lead to less improvement to the environment than would be justified by its cost and complexity, and that emphasis should be placed on more effective planning. The use of a Noise Burden Factor equal to the number of inhabitants seriously disturbed multiplied by 365 and divided by the number of passengers leaving the airport per year is suggested. Noise Burden Factors for major US and UK airports are compared. C K D

**A76-39598** Co-operation and diversification W J Strang (British Aircraft Corp., Ltd., Bristol, England) *Aeronautical Journal*,

vol 80, May 1976, p 209-212

Special features of design management in cooperative and diversified projects are discussed with particular reference to the aerospace industry. The advantages and limitations of different forms of organization for cooperative projects - direct partnership, prime contractor with risk-sharing subcontractors, prime contractor with subcontractors - are considered. It is argued that stable partnerships in European aerospace must of necessity be multiproject. Political acceptability and industrial efficiency are primary requirements for successful organization of such partnerships. The desirability of developing strong project loyalty is stressed for both single- and multiproject endeavors. Diversification offers the opportunity to exploit skills and facilities in new and profitable areas and to utilize temporary excess manpower. In high technology fields, care must be taken to ensure good communication between design and production teams and to select areas with a large enough market to offset the high cost of research and development. C K D

**A76-39599** Aspects of system procedure development for Concorde and future aircraft J D Hobbs (British Aircraft Corp., Ltd., Commercial Aircraft Div., Bristol, England) *Aeronautical Journal*, vol 80, May 1976, p 213-221 7 refs

The evolution of flight documentation for Concorde is discussed, with special attention given to crew operating procedure. The prototype manual was compiled on the basis of procedures supplied for each system by the groups responsible for its design. Six procedural categories were defined (in order of decreasing severity): red, striped, amber, yellow, standby, and normal. The preproduction flight manual replaced yellow and standby procedures with abnormal procedures. The specific behavioral objective developed by the Boeing Company was used to delineate emergency and abnormal drill and procedure formats. The application of the Cooper scale and system safety assessment techniques to evaluate the safety and handling qualities of the aircraft is discussed, together with the evolution of the Minimum Equipment List. C K D

**A76-39680 #** Correlation interferometric measurement of carbon monoxide and methane from the Canada Centre for Remote Sensing Falcon fan-jet aircraft H W Goldstein, M H Bortner, R N Grenda (General Electric Co., Space Div., Philadelphia, Pa.), R Dick, and A R Barringer (Barringer Research, Ltd., Toronto, Canada) (*Canadian Aeronautics and Space Institute, Aerospace Electronics Symposium, Halifax, Nova Scotia, Canada, Feb 4, 5, 1975*) *Canadian Journal of Remote Sensing*, vol 2, May 1976, p 30-41 5 refs

Measurements of CO on a global scale conducted with the aid of satellites and aircraft are required to solve problems related to an introduction of carbon monoxide into the atmosphere. An instrument, called the correlation interferometer, has been developed for the conduction of the considered measurements. The principles of operation of the instrument are discussed and a description is given of aircraft flight tests which have been carried out to test the suitability of the instrument for the intended applications. G R

**A76-39731** Structural adhesives with emphasis on aerospace applications. Research supported by the US Department of Defense, Grant No. DOD MDA 903-74-C 0167. New York, Marcel Dekker, Inc. (Treatise on Adhesion and Adhesives. Volume 4), 1976. 258 p. \$24.50

This book examines current knowledge and future needs in the synthesis and formulation of structural adhesives used in aircraft, missiles, and manned as well as unmanned spacecraft. The present state of the art in high performance adhesives for such purposes is summarized, and applications of structural adhesive bonding for aerospace systems are reviewed. Various structural adhesives are categorized according to the physical form in which they are used, the role of interfaces is discussed from the viewpoint of physical chemistry, and problem areas directly associated with the production of a bonded structure are identified. Solutions to each of the

problem areas are recommended, and the manufacture and processing of adhesives are considered. The behavior of polymeric adhesives in joints is investigated, emphasizing large deformations, failure mechanisms, and types of failure. Design, analysis, and test methods for structural adhesives are outlined along with integrated test programs and test strategies for establishing the performance and reliability of adhesive-bonded systems. Existing methods of technology transfer in the field of structural adhesives are reviewed.

F G M

**A76-39734 #** Electromagnetic forces and moments of engines with tilting rotors (Elektromagnitnye sily i momenty dvigatelei s katiashchimsia rotorom) A A Farbovskii *Akademii Nauk SSSR, Izvestiia, Energetika i Transport*, May-June 1976, p 60-67 6 refs In Russian

The electromagnetic forces and moments of different types of engines with low-power tilting rotors are investigated and compared. It is shown that the largest electromagnetic forces and moments develop in the synchronous engine, these have relatively small fluctuations. The synchronous-reluctance motor is characterized by minimal forces and moments and large fluctuations.

C K D

**A76-39833** General Dynamics F-16 W G Holder and W D Siuru, Jr. Fallbrook, Calif., Aero Publishers, Inc. (Aero Series Volume 26), 1976 104 p \$6 95

The present book describes the F-16 lightweight fighter and recounts how it was developed and tested. Lightweight fighters built since the end of World War I are examined, the specifications of the F-16 are outlined, and its combat capability is evaluated. Flight-test accomplishments of the YF-16 prototype are summarized, the flight-test program is described, and the F-16 development and production schedule is presented. Similarities between the F-16 and NASA's HiMAT research aircraft are noted. The development of the two-seat F-16B is discussed along with the competition among the F-16, the Mirage F1E, and the Swedish Viggen 37E. The U.S. Navy's F-18 air combat fighter is described, and the combat capability of the F-16 is compared with that of the Soviet MiG-21, MiG-23, and MiG-25. Numerous black and white and color photographs supplement the text.

F G M

**A76-39843 \* #** Conceptual design of reduced energy transports M D Ardema, M Harper, C L Smith, M H Waters, and L J Williams (NASA, Ames Research Center, Moffett Field, Calif.) *Journal of Aircraft*, vol 13, Aug 1976, p 545-550 8 refs

The paper reports the results of a conceptual design study of new near-term fuel conservative aircraft. A parametric study was made to determine the effects of cruise Mach number and fuel cost on the optimum configuration characteristics and relative economic performance. Supercritical wing technology and advanced engine cycles were assumed. For each design, the wing geometry was selected to maximize an economic figure of merit which reflects the potential rate of return on investment. Based on the results of the parametric study, a reduced energy configuration was selected. Compared with existing transport design, the reduced energy design has a higher aspect ratio wing with lower sweep, and cruises at a slightly lower Mach number. It yields about 30% more seat-miles/gal than current wide body aircraft. At the higher fuel costs anticipated in the future, the reduced energy design has about the same economic performance as existing designs with the same technology level. As an example of a far term technology application, a design with a composite material wing was also investigated.

(Author)

**A76-39847 \* #** Scanning laser Doppler velocimeter system simulation for sensing aircraft wake vortices J A L Thomson and J C S Meng (Physical Dynamics, Inc., Berkeley, Calif.) *Journal of Aircraft*, vol 13, Aug 1976, p 605-613 12 refs Contract No NAS8-28984

A model that simulates the interaction of a laser Doppler velocimeter with an aircraft wake flowfield is described. A hydro-

dynamic model is developed which represents the trailing vortex sheet and wind shear as discrete free vortices distributed over a two-dimensional grid. A sensor model is formulated for scanning both in range and in angle to produce a fan beam configuration without frequency translation. Output of this model is a frequency spectrum vs both range and angle. Once the spectrum is evaluated, simulations of the data analysis procedure are carried out. Patterns of various features of the signature are presented in range-elevation angle plots. The problem of locating the vortex centers is discussed as a pattern recognition problem and as a point target problem.

S D

**A76-39848 #** Design for minimum fuselage drag J Roskam (Kansas, University, Lawrence, Kan.) and G Fillman *Journal of Aircraft*, vol 13, Aug 1976, p 639, 640

Designers of general aviation aircraft must have a method for sizing the fuselage such that zero-lift drag is minimized under constraints of cabin volume (utility) and stability. A method is proposed for minimizing the sum of fuselage and empennage friction drag under constant directional and longitudinal stability constraints. The method is applied to three general aviation aircraft, and it is found that none of them is optimum from a drag viewpoint. The method may be extended to include the effect of weight along with other stability and control constraints.

S D

**A76-39855 #** A survey of transonic aerodynamics J M Wu and T H Moulden (Tennessee, University, Tullahoma, Tenn.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-326* 38 p 294 refs Army-USAF supported research

The history of research on transonic regimes is reviewed, with remarks on the typical phenomenology of transonic flows. The current status of research into transonic flow behavior is reviewed extensively, covering the topics local supersonic flow region, generation of shock waves, shock waves and drag rise, shock-free airfoils, approximation techniques and finite difference methods, hodograph techniques, inviscid unsteady flow, wall interference, wind tunnels with adaptive walls, viscous-inviscid interactions, flow separation, interactions of shocks and boundary layer, wake/separation interaction, and high Re tunnels.

R D V

**A76-39856 #** Calculation of the transonic oscillating flap with 'viscous' displacement effects R J Magnus and H Yoshihara (General Dynamics Corp., Convair Div., San Diego, Calif.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-327* 14 p 8 refs

The 'Euler' finite difference method is used to calculate the flow over the NACA 64A-006 airfoil at  $M = 0.875$  with a quarter chord flap oscillating at a reduced frequency based upon the airfoil chord of 0.468. Viscous displacement due to shock-induced separation and occurring on the flap are determined by a viscous ramp phenomenology. Here in an inviscid calculation shape modifications, simulating the viscous displacement, are first modeled in the steady case by prescribing the measured pressures instead of the surface slopes along those portions of the airfoil where the viscous effects are significant. In the unsteady case the modeled shock-induced ramps and the aft flap ramps are tied respectively to the instantaneous shock and to the flap position. The resulting unsteady pressure distributions for the inviscid case and with the viscous ramps are compared to the experimental results of Tijdeman and Schippers. The addition of the viscous ramps was found to reduce significantly the large disparity between the inviscid and experimental distributions found earlier.

(Author)

**A76-39865 \* #** A higher order panel method for linearized supersonic flow F E Ehlers, F T Johnson, and P E Rubbert (Boeing Co., Seattle, Wash.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-381* 13 p 13 refs Contract No NAS2-7729



A higher order panel method using linearly varying source and quadratically varying doublet distributions for computing linearized supersonic flow over arbitrary wings and bodies is described. With tangential mass flux boundary conditions on circular cones at angles of attack, the source panel method gave pressure distributions which are in excellent agreement with exact nonlinear theory. The numerical source panel method was demonstrated to be very stable by randomly panelling an axially symmetric body. For wings with thickness and camber, both the source and doublet panel methods yield excellent agreement with exact linearized solutions. Computational experiments indicate that the use of exact surface panelling in lieu of linearized boundary conditions for wings provides better agreement with higher order theory and with experiment. (Author)

**A76-39867 \* #** Three dimensional supersonic flows with subsonic axial Mach numbers. F. Marconi (Grumman Aerospace Corp., Bethpage, N.Y.) and G. Moretti (New York, Polytechnic Institute, Brooklyn, N.Y.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-383* 9 p. Contract No. NAS1-14162

A numerical approach is presented for the computation of flows in which the component of velocity in the selected marching direction is subsonic although the total velocity is supersonic. A local coordinate rotation procedure is employed together with an implicit differencing scheme. Complex coordinate transformations and time-consuming iterations are avoided. The implementation of the described approach is illustrated with the aid of a two-dimensional problem. An application in the case of three dimensional flows is also discussed. G. R.

**A76-39872 \* #** Numerical studies of three-dimensional breakdown in trailing vortex wakes. J. E. Hackett and P. F. Evans (Lockheed-Georgia Co., Marietta, Ga.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-416* 11 p. 11 refs. Contract No. NAS2-8651

The development of dangerous vortex wakes trailing between aircraft for appreciable distance downstream, and posing hazards to following aircraft, is calculated using finite element three-dimensional relaxation methods. Near wake, middle-wake, and far-wake conditions are delineated. Vortex system finite lifetimes can be calculated with greater facility owing to the inclusion of a self induction term in the solution dependent upon local curvature and vortex core radius. Looping and convergence phenomena are studied for single vortex pairs, twin pairs, and multiple pairs. Proportions of flap span and wing span are shown to affect the time to convergence of vortex pairs. The self-induction term renders the convergence time of vortices a sensitive function of wavelength. Wakes trailing between wide body ('Jumbo') aircraft are also examined. R. D. V.

**A76-39873 \* #** An improved method for the prediction of completely three-dimensional aerodynamic load distributions of configurations with leading edge vortex separation. P. E. Rubbert (Boeing Aerospace Co., Seattle, Wash.), P. Lu (Boeing Computer Services, Inc., Seattle, Wash.), G. W. Brune, and J. A. Weber (Boeing Commercial Airplane Co., Seattle, Wash.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-417* 8 p. 19 refs. Contract No. NAS1-13833

The application of a higher-order subsonic potential flow panel method to the solution of three-dimensional flow about wing and wing-body combinations with leading edge vortex separation is presented. The governing equations are the linear flow differential equation and nonlinear boundary conditions which require that the flow be parallel to the wing and body surfaces and that the free vortex sheet, springing from the leading and trailing edges, be aligned with the local flow and support no pressure jump. The vortex core is modeled as a simple line vortex which receives vorticity from the free sheet through a connecting sheet. The Kutta condition is imposed on all appropriate edges of the wing. This set of nonlinear equations is solved by an iterative procedure. The Goethert rule accounts for

compressibility. The method has been programmed for the CDC 6600 Delta wings, gothic wings, arrow wings, cambered wings, and wing with body have been analyzed. Initial studies involving variations of panel density, vortex sheet sizing, Jacobian update, and initial geometry demonstrate that the present method generally exhibits good convergence characteristics. (Author)

**A76-39874 #** Entrainment method for V/STOL ejector analysis. P. M. Bevilacqua and J. K. McCullough (Rockwell International Corp., Columbus Aircraft Div., Columbus, Ohio.) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-419* 7 p. 10 refs.

A thrust augmenting ejector is a pneumatic device in which the turbulent transfer of kinetic energy from a primary jet to air drawn from the atmosphere produces an increase in the primary thrust. A momentum integral method has been developed for estimating the performance of V/STOL aircraft ejectors from empirical jet entrainment data. The analytic results are compared with tests of a Coanda type ejector, and the method is used to examine the effect of changes in the shroud configuration. The classical results of one dimensional ejector theory, that augmentation increases with the inlet and diffuser area ratios and the rate of entrainment, are qualified by the effect of changes in the ejector length. (Author)

**A76-39905 #** Armament exhaust structural heating effects on the F 14 aircraft. S. Z. Fixler (Grumman Aerospace Corp., Bethpage, N.Y.) *American Institute of Aeronautics and Astronautics, Thermophysics Conference, 11th, San Diego, Calif., July 14-16, 1976, Paper 76-445* 11 p. 6 refs.

This paper discusses the predicted and actual structural heating effects on the F 14 Tomcat fighter aircraft resulting from air to air missile and gun exhaust plume impingement. Of particular interest are the thermal effects that the exhaust plumes of the Sidewinder and Sparrow missiles and Vulcan multibarrel gun produce on critical structure. This study was undertaken to point out the initially foreseen problem areas and some ways of dealing with them. The implementation of test-dictated design modifications is examined. Analytically predicted and measured thermal responses of critical aircraft structure to the Sidewinder, Sparrow, and Vulcan gun exhaust plumes are presented. Thermostructural aspects (including instrumentation) of ground and in-flight test firings are discussed along with in service experience of plume-impinged structure. (Author)

**A76-39992 #** Linearized nonequilibrium flow of a fuel mixture during the interaction of two supersonic gas streams (Linearizovannoe neravnovesnoe techenie goruchey smesi pri vzaimodeistvii dvukh sverkhzvukovykh gazovykh potokov). M. M. Gilinskiy. *Akademiya Nauk SSSR, Izvestiya, Mekhanika Zhidkosti i Gaza*, May-June 1976, p. 156-160. In Russian.

The paper examines the problem of the supersonic stream of a premixed fuel gas mixture with another gas stream. An interaction of this sort takes place during tangential jet injection through the side of a flight vehicle, during distributed supersonic injection of a fuel mixture at a small angle to the surface and during combustion in the tail shock at the trailing edge of a thin airfoil. Combustion in the shock region is described by irreversible exothermic reactions. The jet interaction, perturbed due to heat transfer, is studied on the basis of linearized gasdynamic equations. B. J.

**A76-39995** Approximate solutions of fluid mechanics and their physical interpretation (Naheungslosungen der Stromungsmechanik und ihre physikalische Deutung). E. Truckenbrodt (Munich, Technische Universität, Munich, West Germany). *Zeitschrift für Flugwissenschaften*, vol. 24, July-Aug 1976, p. 177-187. 15 refs. In German.

Approximate relations for the determination of frictional drag

in the case of a planar plate with a turbulent boundary layer are examined. The momentum equation of fluid mechanics provides the basis for the theoretical study of the problem. Other approximate solutions considered are related to the problems of sudden pipe enlargement, unsteady tank efflux, and lift on an airfoil. The discussed examples illustrate that an analysis of the basic considerations involved in the derivation of an approximate solution can provide important information regarding the quality of the selected mathematical model concept. G R

**A76-39996** The jet flap wing near ground, giving particular attention to large angles of attack and jet flap angles (Der Strahlklappenflugel in Bodennahe unter besonderer Berucksichtigung grosser Anstell- und Strahlklappenwinkel) R Lohr (Ruhr-Universitat, Bochum, West Germany) *Zeitschrift fur Flugwissenschaften*, vol 24, July-Aug 1976, p 187-196 12 refs In German

An investigation has been conducted concerning the effect of the ground on an airfoil, taking into account the case in which a jet emerges at the trailing edge. The characteristics of frictionless planar flow around the airfoil are calculated with the aid of the singularity method. A system of nonlinear integral equations is obtained for the singularity distributions and jet characteristics. An iterative approach is used to solve the system of equations. The derived relations provide values for the pressure distribution, the jet characteristics, the lift, and the moment as a function of the angle of attack, the jet flap angle, and the distance from the ground. The theoretical results are confirmed by experimental data. The nonlinear theory developed represents a significant improvement with respect to the linear theory. G R

**A76-39997** A method for computation of the aerodynamic coefficients of missiles in the high Mach number range for small angles of attack and tail deflection and arbitrary roll angles (Ein Verfahren zur Berechnung der aerodynamischen Beiwerte von Flugkorpern im hohen Unterschall fur massive Anstell- und Ruderausschlagwinkel und bei beliebigen Rolllagen) H W Stock (Dornier GmbH, Friedrichshafen, West Germany) *Zeitschrift fur Flugwissenschaften*, vol 24, July-Aug 1976, p 196-205 12 refs In German Bundesministerium der Verteidigung Contract No T-R-420-R-4100-43023

A simple and rapid method is presented for calculating the aerodynamic coefficients of missiles in the high Mach number range for small angles of attack and of tail deflection and arbitrary roll angles. The validity of the method is limited to the following configurations: cylindrical bodies of circular cross-section with different nose shapes, sharp cones, sharp ogives and hemispheres, arbitrary position of the wings of any plan form, consisting of flat plates with sharpened leading and trailing edges. The calculation uses the modified Newtonian theory, the exact expression for oblique shocks and the Prandtl-Meyer theory. Any interference between the components of the missile is neglected. For the calculation of the forces acting on the wing only the wing area but not the plan form is of importance. The resulting force acts in the center of the wing area. The agreement between the calculated results and experiments is very satisfactory. (Author)

**A76-39999** Applications of a digital evaluation method for the determination of the dynamic characteristics of a linear elastomechanical system on the basis of impulse responses (Anwendungen und Erfahrungen mit einem digitalen Auswertverfahren zur Bestimmung der dynamischen Kenngrossen eines linearen elastomechanischen Systems aus Impulsantworten) K D Strutz, N Cottin, and K Eckhardt (Vereinte Flugtechnische Werke-Fokker GmbH, Bremen, West Germany) *Zeitschrift fur Flugwissenschaften*, vol 24, July-Aug 1976, p 209-219 In German

The theoretical basis for the evaluation method is examined and approaches for error compensation in the case of data with errors are discussed. Possibilities for the practical employment of the considered method are illustrated with the aid of theoretical examples and studies related to flight vibration tests. The vibration tests have

been conducted with the VFW614 aircraft. The results of the performed calculations are represented in a graph. G R

**A76-40034 \*** The art and science of rotary wing data correlation J M Drees (Bell Helicopter Textron, Fort Worth, Tex.) (NATO, AGARD, Symposium on Flight/Ground Testing Facilities Correlation, Valloire and Modane, Savoie, France, June 1975) *American Helicopter Society, Journal*, vol 21, July 1976, p 2-12 17 refs Contracts No NAS2-7212, No NAS1-11352, Grants No DAAJ02-73-C-0092, No DAAJ02-73-C-0086, No DAAJ02-69-C-0098

This paper presents an overview of the correlation of helicopter rotor performance and loads data from various tests and analyses. Information is included from U.S. Army-sponsored tests conducted by Bell Helicopter Company for free flight full-scale tests in the NASA-Ames 40 x 80 wind tunnel, one-fifth scale tests in the NASA-Langley Transonic Dynamics Tunnel, and small scale tests of a rotor in air. These test data are compared with each other, where appropriate, and with calculated results. Typical examples illustrate the state of the art for correlation and indicate anomalies encountered. It is concluded that a procedure using theoretical analyses to aid in interpretation and evaluation of test results is essential to developing a science of correlation. (Author)

**A76-40035** Application of simplified inflow models to rotorcraft dynamic analysis R A Ormiston (U.S. Army, Air Mobility Research and Development Laboratory, Moffett Field, Calif.) *American Helicopter Society, Journal*, vol 21, July 1976, p 34-37 8 refs

A dynamic inflow model relating various components of inflow to the integrated aerodynamic forces and moments acting on the rotor, and illustrating the linear relation between these forces and moments and perturbation inflow components, and blade flapping dynamics are analyzed. The application of inflow models to eigenvalue analyses of helicopter dynamics is discussed. These eigenvalue analyses find their main use in flight dynamics stability studies and in investigation of control or low-frequency rotor blade elastic stability. A simple case of blade flapping dynamics of a helicopter in the hover mode is used as an example. Flapping motion of a spring-restrained centrally hinged rigid blade is investigated. Applications of more elaborate dynamic inflow models are indicated. R D V

**A76-40036 \*** A note on correlation description J L McCloud, III (NASA, Ames Research Center, Moffett Field, Calif.) *American Helicopter Society, Journal*, vol 21, July 1976, p 37-39

The paper suggests some modifications to definitions of correlation functions made by Freeman and Bennett (1974) specifically for comparing measured quantities with those predicted by rotor theories, with reference to rotorcraft flight simulation. Special attention is paid to the quality of correlation, determined by a quality factor relating the measured and computed entities. Correlation criteria (mean load and rotor performance, overall amplitude and phase, harmonic altitude and harmonic phase) are examined, along with phase angle correlation criteria (harmonic phase defined by sine-cosine relation and harmonic phase defined by a first positive peak rotor azimuth position). B J

**A76-40037** Data transmission in integrated avionics systems (Echanges de donnees au sein de systemes integres d'avionique) P F Edouard (Societe Nationale Industrielle Aerospatiale, Paris, France) and M-B Emery (Integration Systemes Pilotage et Navigation des Aeronaves, France) *Navigation (Paris)*, vol 24, July 1976, p 277-294 In French

The use of digital data bus systems to provide digital links between the various components of integrated avionics systems is examined. Data buses are shown to offer interconnection and surveillance simplicity and system flexibility and to impose the following constraints: the need to standardize message format, the limitation of data rate and the need of management unity. Design criteria for buses are outlined, including link structure, transmission procedures, the choice of data support, modulation and interface circuits, and transmission efficiency. An experimental bus system - SIGMA

installed on a Caravelle aircraft and controlling the cabin pressure regulation system is described. Functional applications of the bus system are considered with attention directed to triplex and '2 plus 2' systems. B J

**A76-40041 # The design and development of glass wind-screens for wide-bodied aircraft** R S Bruce (Triplex Safety Glass Co., Ltd., Birmingham, England) *Aircraft Engineering*, vol 48, July 1976, p 4-6, 8

The design and development of high strength, multiple glass ply windshields in a flat configuration for the A300B Airbus and in a curved configuration for the Boeing 747 are discussed. Both shields are based on Triplex construction using high strength 'TEN TWENTY' glass and a polyvinyl butyral interlayer. The windshields are clamped into the aircraft structure to isolate them mechanically and thermally. In the 747 design, de-ice/de-mist capability is provided by the HYVIZ vacuum-deposited, metal oxide coating, characterized by high light transmission and good adhesion. This shield has performed successfully for over 10,000 hours of flight time. C K D

**A76-40042 # Control of quality in an aero-engine factory.** E T Trewin (Rolls-Royce /1971/, Ltd., Derby, England) *Aircraft Engineering*, vol 48, July 1976, p 9-12, 14-18, 20, 21

The organization of quality control in the Aero Division of Rolls-Royce is described. Quality policies and objectives are outlined. Special attention is given to the delegation of responsibilities between quality engineers and inspectors. The application of the procedures considered in the product center responsible for the production of turbine wheels, compressor disks and shafts is discussed in detail. The inspection procedures in operation at different stages of production are described. C K D

**A76-40124 # Effect of mass addition on the boundary layer of a hemisphere at Mach 6** A Demetriades, A J Laderman, L Von Seggern (Aeronutronic Ford Corp., Newport Beach, Calif.), A T Hopkins (USAF, Space and Missiles Systems Organization, Los Angeles, Calif.), and J C Donaldson (ARO, Inc., Tullahoma, Tenn.) *Journal of Spacecraft and Rockets*, vol 13, Aug 1976, p 508, 509. Contract No F04701-71-C-0035

Hypersonic wind tunnel tests were used to study the effects of mass injection on boundary layer development and transition on a smooth spherically blunted cone with essentially zero heat but with finite mass transfer rates. The 5 degree half angle cone made of porous sintered stainless steel was operated adiabatically at a nominal Mach 6 continuous flow condition. Boundary layer profiles were derived from pitot-tube measurements. Boundary layer growth with and without injection was compared, and the relation between the integrated mass flow, the resulting location of transition (in degrees from the stagnation point), and the hemisphere Reynolds number was examined. It appears that mass addition increases laminar boundary layer thickness and produces changes in the velocity profile. B J

**A76-40126 # Seeking failure free systems** R E Merkle (USAF, Norton AFB, Calif.) *Air University Review*, vol 27, July-Aug 1976, p 41-50

The need for developing failure-free systems for USAF aircraft is advocated, with figures relating major aircraft accidents and costs. Fault tree analysis is described and applied to fire threat and prevention on fighter aircraft. B J

**A76-40179 A functionally redundant altimeter** R N Clark (Washington, University, Seattle, Wash.), C J Masreliez (Boeing Commercial Airplane Co., Washington, University, Seattle, Wash.), and J W Burrows (Boeing Computer Services, Inc., Seattle, Wash.) *IEEE Transactions on Aerospace and Electronic Systems*,

vol AES-12, July 1976, p 459-463. 9 refs

A scheme to provide redundant sensor data in an automatic control system using the principle of functional redundancy is described. Normally there are three redundant radar altimeters used in the terminal phase of automatic landing of jet transport airplanes. This scheme replaces one of these altimeters with a data processing scheme based on a Kalman filter. The filter is driven by altitude rate and acceleration signals from the air data computer and vertical accelerometer. A special initialization technique employs the two altimeter signals. The feasibility of this scheme is indicated by tests in which data obtained from these several sensors during flight tests are used to drive the functionally redundant altimeter. (Author)

**A76-40180 Energy management for fuel conservation in transport aircraft** R F Stengel and F J Marcus (Analytic Sciences Corp., Reading, Mass.) (*Institute of Electrical and Electronics Engineers, National Aerospace and Electronics Conference, Dayton, Ohio, May 18, 1976*) *IEEE Transactions on Aerospace and Electronic Systems*, vol AES-12, July 1976, p 464-471. 11 refs. Contract No F33615-75-C-3039

Optimal control techniques have been applied to the problem of conserving fuel in C-141A aircraft. Numerical results form the basis for designing an on-board energy management system, which can automatically command fuel-optimal climb, cruise, and descent flight paths for a majority of this aircraft's missions. (Author)

**A76-40190 Kevlar 49/Thornel 300 hybrid fabric composites for aerospace applications** C Zweben and J C Norman (Du Pont de Nemours and Co., Inc., Wilmington, Del.) *SAMPE Quarterly*, vol 7, July 1976, p 1-10. 8 refs

This paper presents tensile, compressive and impact properties of Kevlar aramid Thornel 300 graphite hybrid fabric composites. Two types of fabrics were considered: (1) one with equal numbers of fibers in the warp (0 deg) and fill (90 deg) directions, designated a balanced fabric, and (b) one with most of the fibers oriented in the warp direction, called a unidirectional fabric. Two ratios of 'Kevlar' 49 to 'Thornel' 300 are considered for the balanced fabric, 25/75 and 50/50, along with all 'Kevlar' 49 and all graphite fabrics. A 50/50 ratio in the warp direction was used for the unidirectional fabric. Results are compared with data for (0/90) laminates made from hybrid tape. Although the reinforcement efficiencies of fabrics are not as good as those of collimated tapes, hybrid fabric composites offer a balance of mechanical properties, impact resistance and fabrication cost savings that makes them attractive for many applications. A brief selective survey of recent hybrids programs is presented. (Author)

**A76-40312 Heat recovery from multi-turbine installations** A E Smith (Exxon Co., U.S.A., Tyler, Tex.) and G T Schaefer, Jr (Exxon Co., U.S.A., Baytown, Tex.) (*Society of Petroleum Engineers and AIME, Annual Fall Technical Conference and Exhibition, 50th, Dallas, Tex., Sept 28-Oct 1, 1975*) *Journal of Petroleum Technology*, vol 28, June 1976, p 639-644. 5 refs

An approach is presented for the process and mechanical design of a system that recovers heat energy from the exhaust gases of parallel turbines and uses this energy in a gas plant process. Attention is focused on major design criteria and concepts for successful energy recovery systems at two Exxon gas processing plants. The discussion covers heat transfer fluid, heat exchanger design, exhaust collection, supplemental firing, stack design, special structural and insulation requirements, automatic control system, and actual field installations. The considerations should serve only as a foundation and guide for extending the concept to other energy recovery opportunities. S D

**A76-40374 Gas turbine engine pollution** A M Mellor (Purdue University, West Lafayette, Ind.) *Progress in Energy and Combustion Science*, vol 1, no 2-3, 1976, p 111-133. 103 refs. Research supported by the U.S. Environmental Protection Agency.

and General Motors Corp

Recently set U S Environmental Protection Agency standards and Air Force goals for aircraft jet engine emissions of unburned hydrocarbons, CO and NO<sub>x</sub> are reviewed. Suggested design modifications for gas turbine combustors to meet these requirements are discussed via a generalized physical model of the liquid fuel spray combustion process which is consistent with both engine and combustor exhaust plane pollution measurements and data obtained within burners. This model is used to show why some analytical/numerical combustor modeling efforts succeed in correlating emissions and may eventually become useful design tools for next-generation, low emissions Brayton cycle engines. (Author)

**A76-40395** A validation study of the mixed-foil concept for high-speed hydrofoils. D P Wang and Y T Shen (U S Naval Material Command, David W Taylor Ship Research and Development Center, Bethesda, Md.) *Journal of Ship Research*, vol 20, June 1976, p 85-94. 20 refs. Navy-supported research.

A hydrodynamic validation study of the concept of the mixed foil has been conducted. A mixed foil is a streamlined hydrofoil equipped with a flap or other device which, above a certain speed, can be activated so as to change the flow around the foil into a supercavitating flow. At take-off and at moderate speeds, a mixed foil is operated as a subcavitating foil, at high speeds, it is operated as a supercavitating foil. During high-speed operations, a reduction in the wetted planform area of a mixed foil is proposed. The present study produces a design outline for the mixed foil and identifies essential problems which should be studied in the future. The analysis is illustrated by using hydrofoils with plano-convex sections. The lift-to-drag ratios at takeoff and at 45-knot and 83-knot cruising speeds are obtained. (Author)

**A76-40418** The prediction of air travel and aircraft technology to the year 2000 using the Delphi method. J M English and G L Kernan (California, University, Los Angeles, Calif.) *Transportation Research*, vol 10, Feb 1976, p 1-8. 8 refs. Research supported by the U S Department of Transportation.

The Delphi method is an iterative information seeking technique which is used to obtain group consensus on uncertain events by having individual members of the chosen group provide estimates in private. A significant feature of Delphi is controlled feedback achieved by conducting the exercise in a series of rounds and communicating the results of previous rounds to the participants. A Delphi forecast for air traffic and aircraft technology during 1990-2000 was sponsored by the Department of Transportation Climatic Assessment Study. Questionnaire design is described and traffic projection and aircraft technology questionnaires are provided. Questionnaire results are summarized, with discussion of such subjects as the Concorde, U S and USSR supersonic aircraft, and forecasts on route patterns, environmental factors, and passenger and cargo traffic. B J

**A76-40576** Europe's tornado. *Flight International*, vol 110, Aug 7, 1976, p 330-335.

Flight test results of prototypes of the Panavia Tornado are discussed. In a total of about 500 hr flying time, the airframe and avionics have given satisfactory performance. Complete evaluation of the performance envelope has been delayed because of the relatively underdeveloped state of the engine, the present RB 199-02 engines are about 17% down on thrust at low level and about 30% at altitude. The introduction of auto-sweep is under consideration. Authorization has been received for the production of the first 40 aircraft, with initial deliveries scheduled for 1979. C K D

**A76-40578** A theoretical study of body drag in subcritical axisymmetric flow. D F Myring (Salford, University, Salford, England) *Aeronautical Quarterly*, vol 27, Aug 1976, p 186-194. 8 refs.

Body drag is predicted in subcritical axisymmetric flow by a

method which requires only detailed information on body shape, free-stream conditions, and transition point. Fineness ratio alone is not adequate to find the body shape, though calculations for a range of body shapes do conform with the R A S data sheets. Bodies of the same fineness ratio with different body contours are not distinguished by the method. The effect of body shape on drag coefficient, and calculations of body drag by an alternate method, are suggested for checking the accuracy of current data, along with the method proposed. The proposed body drag prediction method does not require empirical data on the pressure distribution around the body, but only on the turbulent boundary layer. R D V

**A76-40581** Measurements in an axisymmetric turbulent boundary layer along a circular cylinder. N Afzal (Aligarh Muslim University, Aligarh, India) and K P Singh (Indian Space Research Organization, Vikram Sarabhai Space Center, Trivandrum, India) *Aeronautical Quarterly*, vol 27, Aug 1976, p 217-228. 26 refs.

In an axisymmetric turbulent boundary layer along a circular cylinder at constant pressure, measurements have been made of mean velocity profile and turbulence characteristics, longitudinal velocity fluctuations, Reynolds shear stress, transverse correlation and spectrum. It has been found that the qualitative behavior of an axisymmetric turbulent boundary layer is similar to that of a two-dimensional boundary layer in the wall region, where as in the outer region the effects of transverse curvature are observed. (Author)

**A76-40583** A review of helicopter IFR operational considerations - The US viewpoint. G A Gilbert. *Interavia*, vol 31, Aug 1976, p 709-713.

The status of the implementation of all weather capability in helicopters and VTOL aircraft, identified with performance under Instrument Flight Rules (IFR), is examined. The advantages of all weather capability in terms of expanding air service and increasing vehicle safety and productivity are discussed, together with the development of instrument approach and departure procedures using U S Government Terminal Instrument Procedures (TERPS) criteria. Interfacing with Air Traffic Control for IFR helicopter operation in airports serving conventional fixed wing aircraft is considered, and helicopter navigation systems for IFR operation are described. C K D

**A76-40584** Autoland starts to pay off for British airways. I D Craig (British Airways /European Div/, London, England) *Interavia*, vol 31, Aug 1976, p 721-724.

The implementation of autoland operation by the British Airways European Division has begun to show significant financial returns, since the route network connects cities largely located in northwestern Europe, an area notorious for its high incidence of rain, drizzle, and fog. The design philosophy adopted in the development of autoland systems for the Hawker-Siddeley Trident, the BAC One-Eleven Series 500, Boeing 747, Concorde, and state of the art TriStar autoland systems is discussed. Common operating problems with all systems have included nuisance and valid autopilot disconnects, nuisance warnings, performance problems, and the in-service rate of autolands. All current systems use ILS Localizer and Glide Slope and radio altimeters as basic guidance. C K D

**A76-40586** The Orao Yugoslav-Romanian combat aircraft. N Cherikov. *Interavia*, vol 31, Aug 1976, p 739, 740.

The design features of the Yugoslav-Romanian combat aircraft Orao are presented. The airframe was developed by the Yugoslav Soko and Romanian IAR aircraft companies. The powerplant of the production aircraft will be a Rolls-Royce Viper engine with a new reheat system. The Orao features high mounted, moderately swept wings with slight anhedral. The horizontal tail plane is low-set. The main landing gear, developed by Messier-Hispano, closely resembles that fitted to the Jaguar. The avionics systems are largely of Western origin. The aircraft, primarily designed for close air support, will

carry two cannon mounted on the fuselage sides beneath the air intakes C K D

**A76-40738** Experimental measurement of fields excited inside the fuselage of an aircraft J Perini (Syracuse University, Syracuse, N.Y.) In Electromagnetic compatibility, Proceedings of the First Symposium and Technical Exhibition, Montreux, Switzerland, May 20 22, 1975 New York, Institute of Electrical and Electronics Engineers, Inc., 1975, p 245-250

Attempts have been made to predict the fields excited inside the fuselage of an aircraft when an EM wave impinges on the windows or other natural openings of such metallic structures. In doing so, the cavity resonances as well as the effects of constructive or destructive interferences were neglected. The purpose of this measurement program is to show that these effects can account for deviations of over plus or minus 20dB of the predicted results and therefore cannot be neglected (Author)

**A76-40742** Crosstalk analysis and design rules for wiring installation in the Saab 37 Viggen aircraft B I Wahlgren and N G Gustafsson (Saab-Scania AB, Linköping, Sweden) In Electromagnetic compatibility, Proceedings of the First Symposium and Technical Exhibition, Montreux, Switzerland, May 20 22, 1975 New York, Institute of Electrical and Electronics Engineers, Inc., 1975, p 314-316

EMC design relating to the separation, shielding, and twisting in order to reduce crosstalk in the Saab 37 Viggen aircraft is examined on the basis of a crosstalk model and crosstalk analysis. The basis of the analysis is the worst case interference level that can be expected to exist within the system. This interference, including the nominal signal and power characteristics, is transformed to the frequency domain. A coupling function, derived by a crosstalk model, is used to calculate the worst case induced interference levels in wires in all cable bundles. The maximum interference level that can be allowed to exist as signal or power characteristics in the bundle is determined by applying the coupling function to the induced level in the wires B J

**A76-40747** Interference survey in military transport aircraft D A Bull and G A Jackson (Electrical Research Association, Ltd., Leatherhead, Surrey, England) In Electromagnetic compatibility, Proceedings of the First Symposium and Technical Exhibition, Montreux, Switzerland, May 20 22, 1975 New York, Institute of Electrical and Electronics Engineers, Inc., 1975, p 351-356

Comprehensive information on the electromagnetic environment existing in modern transport aircraft would be of value to designers and installers of instruments, avionics, and similar equipment. Surveys have been made on a number of transport aircraft to determine the extent of broadband interference generation by electrical equipment and to examine the modes of propagation. It was found necessary to develop specialized measuring equipment and techniques, in particular the multichannel receiver which gives a spectral presentation of the noise in the frequency range from 10 kHz to 30 MHz. The results obtained in the survey have been analyzed and are discussed in relation to the requirements in current specifications for electromagnetic compatibility (Author)

**A76-40806** Noise due to turbulent flow past a trailing edge R K Amiet (United Technologies Research Center, East Hartford, Conn.) *Journal of Sound and Vibration*, vol 47, Aug 8, 1976, p 387-393 27 refs

A theoretical method for calculating far field noise from an airfoil in an incident turbulent flow is extended to apply to the case of noise produced by turbulent flow past a trailing edge, and some minor points of the theory are clarified. For the trailing-edge noise, the convecting surface-pressure spectrum upstream of the trailing edge is taken to be the appropriate input. The noise is regarded as generated almost totally by the induced surface dipoles near the

trailing edge, and equal but anticorrelated noise is radiated into the regions above and below the airfoil wake, respectively. The basic assumption of the analysis, from which these concepts of appropriate input and dominance of dipole sources follow, is that the turbulence remains stationary in the statistical sense as it moves past the trailing edge. The results show that such trailing-edge noise often is quite small, but it might be appreciable for an airfoil with a flow separation or for a blown flap (Author)

**A76-40810** Temperature inversion effects on aircraft noise propagation P J Dickinson (Utah, University, Salt Lake City, Utah) *Journal of Sound and Vibration*, vol 47, Aug 8, 1976, p 438-443

Selected results are presented for a study of the effects of a temperature inversion on aircraft noise propagation near London's Gatwick Airport. Two noise measurement stations were set up, one 0.2 mile from a runway and the other 1.8 miles away. It was expected that the difference in recorded noise levels between the near station and the far station should have been at least 24 dB. However, during one temperature inversion, the attenuation in takeoff noise at the far station was found to range from 31 dB to 3 dB, in fact, most of the measurements were below the expected value. It is noted that during another study at a different airport, one aircraft registered 4 dB more noise at the distant station than at the far station. It is concluded that for a large part of the time, areas prone to temperature inversions may receive noise levels that are 15 to 20 dB above those predicted F G M

**A76-40893** Recent applications of coherent optics in aerospace research J B Abbiss, M J Marchant, and A C Marchant (Royal Aircraft Establishment, Farnborough, Hants, England) *Optical Engineering*, vol 15, May/June 1976, p 202-210 20 refs

Examples of the application of coherent optics in research conducted at the Royal Aircraft Establishment are discussed. Holographic and interferometric techniques used to investigate the stress behavior of aircraft components constructed from composites and conventional materials are described. A simple interferometric technique used to measure vibration amplitudes in the subnanometer range is outlined, and typical results for a piezo electric transducer at frequencies up to 1 MHz are presented. Laser anemometry results obtained in laminar and turbulent wind tunnel air flows at transonic and higher Mach numbers are given, and an application of a modified Fizeau interferoscope for testing panels for aerial cameras is described C K D

**A76-40975** Aeroacoustics Fan noise and control, Duct acoustics, Rotor noise Edited by I R Schwartz (NASA, Ames Research Center, Moffett Field, Calif.) New York, American Institute of Aeronautics and Astronautics, Inc (Progress in Astronautics and Aeronautics Volume 44), Cambridge, Mass., MIT Press, 1976 669 p Members, \$19, nonmembers, \$40

The recent progress in duct acoustic research is reflected by fourteen papers which cover essentially the areas of linear duct acoustics, the characteristics of absorbent materials, and nonlinear duct acoustics. With respect to propagation in ducts, emphasis is placed on computational methods aimed at attaining effective economical modeling of propagation in variable geometry and in hard wall or soft wall ducts. Computational methods developed to reduce computer processing and storage requirements are outlined, along with a wave envelope technique for reducing processing and storage needs. The latter technique is applied to the optimum segmented acoustic duct linear design. A finite difference technique is used in combination with conformal mapping to compute the optimum multisection duct linear design V P

**A76-40976** Aeroacoustics STOL noise, Airframe and airfoil noise Edited by I R Schwartz (NASA, Ames Research Center, Moffett Field, Calif.) New York, American Institute of Aeronautics and Astronautics, Inc (Progress in Astronautics and Aeronautics Volume 45), Cambridge, Mass., MIT Press, 1976 478 p Members,

\$18, nonmembers, \$33

The papers in this volume reflect the progress in aeroacoustic research which has been made in the field of VTOL and V/STOL aircraft noise. The research was directed mainly at developing better methods for predicting noise generation and propagation, at determining the effects of pressure fluctuations on surfaces and interior noise, and at developing noise abatement techniques. Among the topics covered are scrubbing noise of externally blown flaps, propulsive-lift noise of an upper surface-blown flap configuration, the aeroacoustic characteristics of model slot nozzles with straight flaps, fluctuating pressures on aircraft wing and flap surfaces associated with powered lift systems, acoustic characteristics of a large upper-surface-blown configuration with turbofan engines, the effect of forward speed on jet/flap interaction noise, and airframe noise in the far field. V P

**A76-40977**      **Aeroacoustics Acoustic wave propagation, Aircraft noise prediction, Aeroacoustic instrumentation** Edited by I R Schwartz (NASA, Ames Research Center, Moffett Field, Calif.) New York, American Institute of Aeronautics and Astronautics, Inc (Progress in Astronautics and Aeronautics Volume 46), Cambridge, Mass., MIT Press, 1976 340 p. Members, \$16, nonmembers, \$28

The papers in this volume deal with recent research into acoustic wave propagation through the atmosphere and progress in aeroacoustic instrumentation, facilities, and test techniques. Topics include the propagation of aircraft noise over long distances in the lower atmosphere, measured effects of turbulence on the rise time of a weak shock, sound scattering from atmospheric turbulence, saturation effects associated with sound propagation in a turbulent medium, and a computer model of the lightning thunder process. Other papers discuss the development of a computer system for aircraft noise prediction, aircraft flyover noise measurements, and theories and methods for the prediction of ground effects on aircraft noise propagation, for the prediction of airframe aerodynamic noise, for turbine noise prediction, and for combustion noise prediction. Attention is also given to the use of Hartmann generators as sources of high intensity sound in a large absorption flow-duct facility, an outdoor jet noise facility, factors in the design and performance of free-jet acoustic wind tunnels, and the use of a laser shadowgraph for jet noise diagnosis. F G M

**A76-41047**      **Civil helicopter operations with British Airways I - Operations /Halford Memorial Lecture/** J A Cameron (British Airways Helicopters, Ltd., Horley, Surrey, England) *Aeronautical Journal*, vol 80, June 1976, p 253-257

The paper presents a general discussion of experiences encountered during the operations of British Airways Helicopters, and a comparison of the efficiency of helicopters, fixed wing aircraft, and railroads over typical distances encountered in the British Isles. Attention is given to the use of civil helicopters in support of off shore oil and gas exploration. The need for simulators to train helicopter pilots is emphasized, and rough specifications of future generations of civil helicopters for possible operation on such routes as London/Brussels Paris-Amsterdam are outlined. C K D

**A76-41048**      **Civil helicopter operations with British Airways II - Maintenance** M A Parker (British Airways Helicopters, Ltd., Horley, Surrey, England) *Aeronautical Journal*, vol 80, June 1976, p 258-263

The maintenance policies used by British Airways Helicopters in inspecting and servicing their S61 aircraft are discussed. Special attention is given to the problem of developing an equalized maintenance schedule and to difficulties imposed by the lack of redundancy in flight-critical components. The need for cooperation between operators and the manufacturer to improve the maintenance characteristics of helicopters of the present generation is stressed. The modification of the Chinook for civil applications is discussed. C K D

**A76-41175**      **Tornado takes off** *Air International*, vol 11, Sept 1976, p 118-128, 145

The evolution and current status of the Panavia Tornado program are discussed, and major design features of the aircraft are described. The three spool RB 199 engine, based on a Rolls Royce concept and developed by Turbo Union Ltd (Rolls Royce, Fiat, and MTU), incorporates modular construction to facilitate servicing. The bypass ratio is over 1, the pressure ratio is over 20, and the thrust-to-weight ratio is better than 8. The airframe features variable sweep wings with a span of 8.60 to 13.90 meters. The aircraft will have a cruise speed of Mach 2.2 at 10,980 meters, and will carry a built-in armament of two 27-mm cannons developed by LWKA-Mauser. Nine prototypes have undergone flight testing. Britain, Germany, and Italy have issued an initial stated requirement of over 800 aircraft, to be produced over the next 10 years. C K D

**A76-41275**      **A new Mirage - The F1 two-seater (Un nouveau Mirage - Le F1 biplace)** J Morisset *Air et Cosmos*, vol 14, July 17, 1976, p 23-26. In French

A new version of the Mirage F1 entered flight tests in May 1976. The two-seater version was designed to provide an aircraft for familiarizing pilots with the F1 and with the use of its weapons systems. All control systems are present in both places. The installation of the second seat required elongation of the section in front of the fuselage by 30 cm and a 200 kg increase in the empty weight of the equipped aircraft. The internal fuel reserve is reduced by 450 liters, however, all of the operational equipment of the monoplane was conserved with the exception of the internal cannon, which can be replaced by cannon carried in external pods. Flights up to Mach 2.2 have been successfully completed. C K D

**A76-41309**      **Experimental research on vibration damping for flat airplane panels** A I Kashchuk and V V Matveev (*Problemy Prochnosti*, Oct 1975, p 95-100) *Strength of Materials*, vol 7, no 10 July 1976, p 1270-1275 6 refs. Translation

The structural damping capacity of six D16AT duralumin panels of different design was studied as a function of their structural and technological characteristics. It is shown that by using appropriate flexible viscoelastic adhesives (of the type of VK-3), the acoustic resonance vibrations of two-layer panels can be drastically reduced. V P

**A76-41377 \* #**      **Effect of external jet-flow deflector geometry on OTW aero-acoustic characteristics** U von Glahn and D Groesbeck (NASA, Lewis Research Center, V/STOL and Noise Div., Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero Acoustics Conference*, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-499 33 p 7 refs

The effect of geometry variations in the design of external deflectors for use with OTW configurations was studied at model scale and subsonic jet velocities. Included in the variations were deflector size and angle as well as wing size and flap setting. A conical nozzle (5.2 cm diameter) mounted at 0.1 chord above and downstream of the wing leading edges was used. The data indicate that external deflectors provide satisfactory take off and approach aerodynamic performance and acoustic characteristics for OTW configurations. These characteristics together with expected good cruise aerodynamics, since external deflectors are storable, may provide optimum OTW design configurations. (Author)

**A76-41378 \* #**      **Sound generated in the vicinity of the trailing edge of an upper surface blown flap** C K W Tam (Lockheed-Georgia Co., Marietta, Ga., Florida State University, Tallahassee, Fla.) and N N Reddy (Lockheed Georgia Co., Marietta, Ga.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference*, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-503 15 p 31 refs. Contract No NAS1 13870

Far-field noise data indicated that for practical upper surface blown flap configurations, the noise radiated below the flap is dominated by the noise generated in the vicinity of the trailing edge. Sound field by turbulent mixing in the trailing edge wake is investigated experimentally and theoretically. Hot wire measure-

ments were made downstream of the trailing edge to determine the gross turbulence mixing characteristics of the flow. This information is used as input to a theoretical analysis of the sound field. Favorable agreement is found between predicted and measured far-field noise directivities at various frequencies and noise power spectra at various directions (Author)

**A76-41379 \* #** Noise generated by impingement of turbulent flow on airfoils of varied chord, cylinders, and other flow obstructions W A Olsen (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-504* 35 p 20 refs

Noise spectra were measured in three dimensions for several surfaces immersed in turbulent flow from a jet and over a range of flow conditions. The data are free field and were corrected to remove the small contributions of jet noise, atmospheric attenuation and feedback tones. These broadband data were compared with the results of available theories which are only strictly applicable to simple geometries over a limited range of conditions. The available theories proved to be accurate over the range of flow, chord length, thickness, angle of attack, and surface geometries defined by the experiments. These results apply to the noise generated by fixed surfaces in engine passages, the lifting surfaces of aircraft and also to fan noise (Author)

**A76-41380 #** Mechanism of the Mach wave generation B Dutt (Southern California, University, Los Angeles, Calif) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-506* 8 p 11 refs U.S. Department of Transportation Grant No. OS-00002

An experimental investigation is carried out in an attempt to identify the mechanism of the Mach wave generation in an axisymmetric supersonic jet. A fully expanded supersonic jet of Mach number equal to 2 was used and a laser schlieren method was adopted for the study of the near field of the jet. The experiment is based on the preconceived notion that the Mach waves are produced primarily by supersonically moving spatially coherent structures within the jet. Results obtained so far indicate the presence of large scale coherent structures with a detectable passage frequency. Cross-correlation between a number of laser-schlieren beams, along and across the jet, show a tendency for a spatial periodicity along at least twenty diameters of the jet. The measured convection velocities agree with the values deduced from the Mach angles observed on shadowgraphs (Author)

**A76-41381 #** Supersonic jet noise suppression by coaxial cold/heated jet flows D Dosanjh (Syracuse University, Syracuse, N.Y.), K Ahuja (Lockheed-Georgia Co., Marietta, Ga.), M Bassiouni (Terry Corp., Windsor, Conn.), and P Bhutani *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-507* 43 p 29 refs U.S. Department of Transportation Grant No. OS 20094

The paper is centered around the use of coaxial (concentric) multinozzle configurations of suitable geometry and design yielding multijet high speed flows which interact with each other downstream of the exits of the component nozzles and in the process are mutually modified. Each round and annular jet of the coaxial configuration is thrust producing. An analysis of experimental acoustic and optical data on jet noise suppression by coaxial cold/heated jet flows reveals that an annular underexpanded jet operated either cold or heated is inherently quieter than a round jet of the same exit area and operated at the same pressure and temperature. For a given pressure, the noise levels from either an annular or a round heated jet flow increase with increasing temperature. A comparison of the noise variations and reductions from the coaxial jets operated in the cold-cold, cold-heated, and heated-cold modes of operation shows that the cold-cold mode of operation radiates the lowest noise levels for the same operating pressure ratios S D

**A76-41382 \* #** Swirling-flow jet noise suppressors for aircraft engines. I R Schwartz (NASA, Ames Research Center, Moffett Field, Calif) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-508* 17 p 9 refs

Experimental investigations of the effects of swirling the jet exhausts of small turbofan and turbojet engines have indicated significant progress towards predicting and attaining substantial jet noise abatement with minimum thrust losses in large aircraft engines. Systematic variations of the important swirl vane and swirling flow parameters were conducted to determine their effects on jet noise reduction and engine performance. Since swirling flow becomes more effective in reducing jet noise as the density and temperature gradients increase, the significant trends in noise reduction and engine performance that were established by these parametric studies could be projected into potentially greater reductions of sound pressure levels with minimum thrust losses by controlled swirling of the jets of high thrust engines. The density and temperature gradients in the jet exhausts of high thrust engines are larger by comparison with gradients in small engines (Author)

**A76-41383 #** Nozzle exit flow profile shaping for jet noise reduction R W Crouch, C L Coughlin, and G C Paynter (Boeing Commercial Airplane Co., Seattle, Wash) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-511* 14 p 12 refs

Mixing of primary and secondary flows in a conventional turbofan engine provides a means of reducing jet noise. By shaping the nozzle exit velocity profile, noise reduction greater than that resulting from fully mixed flow has been achieved. In a static jet noise experiment, five primary flow nozzles were used with a common secondary nozzle to simulate exhaust flows of turbofan engines with bypass ratios from 1 to 5. Data are shown which relate jet noise to the location, extent and magnitude of the peak velocity region. In general, minimum noise is obtained for inverted profiles where the peak velocity is 5 to 15% greater than the reference uniformly mixed velocity and the area of the peak velocity region is 40 to 50% of the total flow area. The inverted flow profiles produce noise characteristics similar to multielement jet suppressor nozzles, i.e., low frequencies are reduced and high frequencies are increased. It is shown that these spectral effects can be used to obtain a balanced noise signature (Author)

**A76-41384 #** A modeling approach to nonpropulsive noise A G Munson (Douglas Aircraft Co., Long Beach, Calif) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-525* 18 p 12 refs

Nonpropulsive noise measurements made during flyovers of the DC 10 Series 10 airplane with engines at idle power are analyzed. The flyovers were made with flaps and gear retracted, flaps deflected 35 degrees and gear retracted, flaps deflected 35 degrees and gear extended, and the flaps deflected 50 degrees and gear extended. Measurements were made with six tripod-mounted and two flush-mounted microphones. Because flight velocity and height over the microphone varied in the flyovers it was desirable to normalize the data to a common velocity and height, so that results from different configurations could be compared. Once this was done, clear differences in the radiated noise due to deflected flaps and extended landing gear could be found up to a frequency of approximately 4000 Hz. It was also shown that the directivity of the overall sound pressure level in the vertical plane containing the flight path could be modeled with two dipoles, one oriented parallel to the lift vector and the other oriented parallel to the drag vector (Author)

**A76-41387 \* #** Noise measurements in a free-jet, flight simulation facility - Shear layer refraction and facility-to-flight corrections C L Morfey (Southampton, University, Southampton, England) and B J Tester (Lockheed Georgia Co., Marietta, Ga.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Confer-*

ence, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-531 16 p 15 refs Research supported by the Lockheed-Georgia Co and University of Southampton, Contract No NAS3-18540

The conversion of free-jet facility into equivalent flyover results is discussed. The essential problem is to 'calibrate out' the acoustic influence of the outer free-jet shear layer on the measurement, since this is absent in the flight case. Results are presented which illustrate the differences between current simplified models (vortex-sheet and geometric acoustics), and a more complete model based on the Lilley equation. Finally, the use of geometric acoustics for facility-to-flight data conversion is discussed. (Author)

**A76-41388 \* # Development of a technique for inflight jet noise simulation** I, II W S Clapper, E J Stringas (General Electric Co., Aircraft Engine Business Group, Cincinnati, Ohio), R Mani (General Electric Co., Schenectady, N.Y.), and G Banerian (NASA, Propulsion Branch, Washington, D.C.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-532* 31 p 19 refs U.S. Department of Transportation Contract No. OS-30034

Several possible noise simulation techniques were evaluated, including closed circuit wind tunnels, free jets, rocket sleds and high speed trains. The free jet technique was selected for demonstration and verification. The first paper describes the selection and development of the technique and presents results for simulation and in-flight tests of the Learjet, F106, and Bertin Aerotrain. The second presents a theoretical study relating the two sets of noise signatures. It is concluded that the free jet simulation technique provides a satisfactory assessment of in-flight noise. C K D

**A76-41389 # Impedance theory and measurements of single- and multi-layer liners in a duct with flow** A B Bauer (Douglas Aircraft Co., Long Beach, Calif.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-539* 12 p 19 refs

The impedance of a point-reacting liner consisting of a thin, porous surface sheet backed by cavities filled with air or with porous materials has been predicted mathematically for a duct with flow. The mathematical model has been compared with experimental results obtained by using the two-microphone technique for various liners mounted in a 1-foot square duct with flow at Mach numbers of 0 to 0.6. The predicted and the measured sound pressures were found to be in good agreement for liners consisting of a single layer of either air-filled or porous cavities covered by a thin porous sheet. As expected, the porous-cavity liners have a wider attenuated bandwidth and a higher attenuation at high frequencies than the air-cavity liners. Since porous cavities might be considered to be the equivalent of a large number of layers of air spaces separated by layers of porous plates, several such multi-layer liners were constructed and tested. However, the multi-layer liners did not perform like a porous cavity liner, and a full understanding of the operation of the multi-layer liners is yet to be attained. (Author)

**A76-41390 \* # Correlation microphone for measuring air-frame noise in large-scale wind tunnels** W F Ahtye and G K Kojima (NASA, Ames Research Center, Moffett Field, Calif.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-553* 17 p 15 refs

A correlation microphone arrangement was used in the test section of the Ames 7- by 10-Foot and 40- by 80-Foot Wind Tunnels in an attempt to reject the reverberant and wind noise. The tests in the 7- by 10-foot wind tunnel covered a frequency range from 400 Hz to 8 kHz while the tests in the 40- by 80-foot tunnel covered the range from 31.5 to 800 Hz. Examination of the experimental data plus calculations of cross-correlations due to reflective noise indicate that the correlation microphone is effective in rejecting microphone wind noise and reverberant noise even at low frequencies, and that the low-frequency background noise monitored by the correlation microphone is reflected noise with a preferred direction from the tunnel drive system. Design studies indicate that this tunnel drive

noise can be reduced substantially through suitable modification of the drive fans and acoustical treatment of the nacelles that house these fans. (Author)

**A76-41391 # Simulation of flight effects on the structure of jet mixing layers for acoustical applications** J-F de Belleval, M Pérulli (ONERA, Châtillon-sous-Bagneux, Hauts-de-Seine, Compiegne, Université de Technologie, Compiegne, Université de Technologie, Compiegne, Oise, France), and O Leuchter (ONERA, Châtillon-sous-Bagneux, Hauts-de-Seine, France) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-559* 16 p 16 refs

The effects of an external flow on the structure of the mean and turbulent flow fields in the mixing layer of round jets are investigated on two different facilities. The results presented in this paper are obtained for the following conditions: (1) ambient temperature flows, Mach number 0.3 for the internal jet, velocity ratio up to 0.5, ratio of the nozzle diameters 3.3; (2) Temperature 900 deg K and Mach number 0.7 for the internal jet, velocity ratios 0 and 0.2, ratio of the nozzle diameters 5. The experimental techniques used for the diagnostics of the turbulence parameters are those of the hot wire for the cold jets and those of the infrared radiation (crossed beam techniques) for the hot jets. Some preliminary results concerning mean velocity and mean temperature, statistical moments and other characteristic parameters of the turbulence are presented. The effects of the velocity ratio on these are discussed in view of acoustical applications. (Author)

**A76-41393 \* # Acoustic radiation and surface pressure characteristics of an airfoil due to incident turbulence** R W Paterson and R K Amiet (United Technologies Research Center, East Hartford, Conn.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-571* 17 p 41 refs Contract No. NAS1-13823

The noise and unsteady surface pressure characteristics of an isolated airfoil in a uniform mean velocity, homogeneous, nearly isotropic turbulence field were investigated. Experiments were performed with a 23 cm chord, two-dimensional airfoil over a Mach number range of 0.1 to 0.5. Far-field noise spectra and directivity as well as surface pressure spectra and cross spectra were obtained. Incident turbulence statistics were documented. Theory applied to predict far field noise and surface pressure characteristics from measured inflow turbulence statistics showed good agreement with measurement. The theoretical formulation represents a first-principles solution providing absolute level prediction without recourse to empirical or adjustable constants, and takes into account compressibility as well as source noncompactness effects. All chordwise portions of the airfoil radiated directly to the far field, the leading edge to the dominant noise producing region. The effect of angle of attack on noise and surface pressures is small. The interaction of incident turbulence of approximately 4 percent intensity with an airfoil was found to be a broadband noise source of high intensity relative to other noise sources. (Author)

**A76-41394 # Design considerations for a novel low source noise transonic fan stage** D B Bliss, R E Hayden, B S Murray (Bolt Beranek and Newman, Inc., Cambridge, Mass.), and P G Schwaab (Avco Corp., Avco Lycoming Div., Stratford, Conn.) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-577* 11 p 10 refs

This paper reports the development and preliminary test results of a low source noise transonic fan of novel design. The intention of the design is to reduce the following acoustic sources: multiple pure tone noise, rotor wake/stator blade interaction noise, and noise due to operating the rotor in distorted or turbulent inflow. Special nonradial blading of the rotor and stator is used to achieve these goals. The rotor blade leading edges are swept so that the normal component of flow to the edge is subsonic at all points along the blade span, thus preventing the occurrence of leading edge shock



waves. The stator vanes were designed to minimize noise generated by rotor wakes incident on the blades. The vanes are progressively swept from root to tip to produce subsonic trace speeds for the unsteady loads along the span. Special aerodynamic and structural design considerations were required to assure the performance and integrity of this unusual blade and vane design, and these are discussed (Author)

**A76-41395 #** Direct combustion generated noise in turbo-propulsion systems - Prediction and measurement D C Mathews and N F Rekos, Jr (United Technologies Corp, Pratt and Whitney Aircraft Div, East Hartford, Conn) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-579* 14 p 17 refs US Department of Transportation Contract No. FA75WA 3663

The development of an improved prediction system for direct combustion noise is discussed. Expressions for acoustic power level, peak frequency and full-scale engine acoustic transmission loss due to combustor/duct coupling and turbine attenuation are derived in terms of readily available performance and geometry parameters from the burner and turbine. New parameters introduced by the prediction system include the effects of fuel nozzle number and burner length. Predictions are in good agreement with noise data obtained from component rig tests on several JT8D burner configurations, and full-scale turbofan engines. The applicability of the system to the prediction of combustion noise levels, spectra and directivity from full scale engines is demonstrated for four turbofan engines (Author)

**A76-41397 #** Forward motion and installation effects on engine noise J E Merriman, R C Good, J K C Low, P M Yee, and G L Blankenship (Douglas Aircraft Co, Long Beach, Calif) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-584* 11 p 24 refs

In order to investigate the effects of forward motion and nacelle installation on airplane flyover noise, static engine and airplane flyover noise data for a refanned JT8D-109 low bypass ratio turbofan engine installed on a DC 9-30 airplane and a CF6-6D high bypass ratio turbofan engine installed on a DC-10-10 airplane were analyzed. Differences between static-projected and flyover noise data are discussed in terms of noise source generation, convective amplification, propagation, and the engine installation. The results presented indicate that each engine noise source should be adjusted separately for forward motion and installation effects and projected to flight conditions as a function of the source path angle, directivity angle, and acoustic range relative to the microphones on the ground (Author)

**A76-41398 #** Evaluation of proposed standards for aircraft flyover noise analysis systems D J Stouder (Douglas Aircraft Co, Long Beach, Calif) and J C McCann (United Technologies Corp, Pratt and Whitney Aircraft Div, East Hartford, Conn) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif, July 20-23, 1976, Paper 76-589* 9 p

The paper discusses a unique test in which identical tape recordings of aircraft flyover noises were analyzed by different organizations to determine the degree of uniformity in data analysis that could be achieved. The test tape consisted of three flyover noise recordings, their calibration signals, and a time code. The results of tape analysis were used to verify the specifications defined in the proposed Aerospace Recommended Practice (ARP) 1264. The values reported were in terms of maximum overall sound pressure level, maximum perceived noise level, maximum tone corrected perceived noise level, and effective perceived noise level. The proposed standard is described, along with the elements of the evaluation test and the analysis systems used. It is concluded that the proposed ARP 1264 is a workable document and addresses the key characteristics of a flyover noise analysis system and that the state of the art in

uniform analysis of aircraft flyover noise has been greatly improved by complying with the specifications of the proposed standard. S D

**A76-41407** Design decisions for a head-up display A R Doucette (Grumman Aerospace Corp, Bethpage, NY) *IEEE Spectrum*, vol 13, Aug 1976, p 28-32

The engineering approach used to solve problems in the original F 14 windshield/head up display (HUD) combiner configuration is outlined. Internal reflection problems were corrected by replacing the inner conductive coating with heated, forced air and by installing a circular polarizer filter combination in the optical path. The primary difficulty - ghost images resulting from multiple reflections between the windshields and the HUD combiner glass - was solved by using the windshield as a combiner. Two approaches to eliminating the birefringence of the windshields are under investigation: the use of special cooling ducts during tempering and the substitution of chemical for thermal tempering. C K D

**A76-41430 \* #** Digital flight control for the NASA 737 airplane L G Malcom and J H Husband (Boeing Commercial Airplane Co, Seattle, Wash) In *Guidance and Control Conference, San Diego, Calif, August 16-18, 1976, Proceedings*

New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 27-33 5 refs Contract No. NAS1-14070 (AIAA 76-1912)

A brief description of the hardware and software for the digital flight control computers for the NASA 737 airplane is given. Software modules include the basic executive, scheduler, redundancy management, software signal selection, system test, mode logic, pitch axis flight control program and the lateral axis flight control program. A more detailed description of the software development effort is given for the digital flight control software. The software development tasks discussed are software requirements development, documentation, control, lab evaluation and formal lab tests. The software development costs are identified and conclusions are drawn concerning the software development effort required to support digital flight control for commercial jet transport applications (Author)

**A76-41431 #** Flight evaluation of a digital multimode flight control system in an A-7D aircraft T R Yechout (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio) and D R Oelschlaeger (Honeywell, Inc, St Louis Park, Minn) In *Guidance and Control Conference, San Diego, Calif, August 16-18, 1976, Proceedings*

New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 34-41 (AIAA 76-1913)

Multimode control laws were formulated and mechanized in a redundant digital flight control system installed in a USAF flight test A-7D aircraft. The control laws were tailored to increase the effectiveness of the pilot in accomplishing the air-to-air and air-to-ground weapons delivery modes. A test program, consisting of 56 flights was conducted to evaluate the multimode system. Results are presented which substantiate the flexibility and performance capabilities of the digital multimode mechanization and which demonstrate the improvements obtained in air-to-air tracking and air-to-ground gunnery missions (Author)

**A76-41451 #** Mini-RPV flight dynamics measurements P O Jarvinen and C F Bruce (MIT, Lexington, Mass) In *Guidance and Control Conference, San Diego, Calif, August 16-18, 1976, Proceedings*

New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 207-214 10 refs ARPA-Army-sponsored research (AIAA 76-1940)

Experimental measurements are presented of the flight dynamic motions of a representative Mini-RPV at altitudes below one kilometer in gusty air at Ft Huachuca, Arizona. Delta wing Mini-RPV airframe motions during open-loop and autopilot flight were measured with an on-board three-axis linear accelerometer/angular accelerometer package while atmospheric gustiness con-

ditions were measured with a gust vane mounted on a boom forward of the aircraft. A 32 channel pulse amplitude modulation telemetry system transmitted the data from the Mini RPV to the ground where it was recorded on magnetic tape and also displayed in real time. Significant data was obtained on vehicle response to gusty air and due to maneuver commands and a summary of the data is presented (Author)

**A76-41461 # Development and evaluation of precision control modes for fighter aircraft** P A Merkel and R A Whitmoyer (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio). In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings. New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 300-308 (AIAA 76-1950)

The Control Configured Vehicle (CCV) Advanced Development Program of the Air Force Flight Dynamics Laboratory is developing advanced flight control concepts for fighter aircraft. A current contracted effort with General Dynamics Corporation has modified a YF-16 aircraft to flight evaluate six uncoupled maneuver modes and an automatic control mode for precision flight path control. This paper describes the design and development of the CCV YF 16 auxiliary Fly-by-Wire flight control system including simulation studies and redundancy tradeoffs. Also discussed are the operational applications of the maneuver modes and preliminary flight test results (Author)

**A76-41463 \* # Digital adaptive control laws for the F-8** G L Hartmann and C A Harvey (Honeywell, Inc., Minneapolis, Minn.). In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings. New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 319-329. 13 refs. Contract No. NAS1 13383 (AIAA 76-1952)

NASA is conducting a flight control research program in digital fly-by-wire technology using a modified F-8C aircraft. The first phase of this program used Apollo hardware to demonstrate the practicality of digital fly-by-wire in an actual test vehicle. For the second phase, conventional aircraft sensors and a large floating point digital computer are being utilized to test advanced control laws and redundancy concepts. As part of NASA's research in digital fly-by-wire technology, Honeywell developed digital adaptive flight control laws for flight test in the F-8C. Adaptation of the control laws was to be based on information sensed from conventional aircraft sensors excluding air data. The control laws were constrained to use only existing elevator, rudder, and ailerons as control effectors, each powered by existing actuators. Three adaptive control laws were successfully designed using maximum likelihood estimation, a Liapunov stable model tracker and a self excited limit cycle concept. The maximum likelihood estimation design was selected as the most promising because of its capability to identify more than surface effectiveness parameters. The adaptive concepts, the control laws and comparisons of predicted performance are described (Author)

**A76-41465 \* # Optimal control of a low wing-loading STOL aircraft** T B Cunningham (Honeywell, Inc., Minneapolis, Minn.). In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings. New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 337-347. 14 refs. Contract No. NAS2 8605 (AIAA 76-1954)

Linear optimal quadratic control theory is applied to a low wing-loading STOL aircraft for ride quality and flight path following. Design criteria include minimum rms response to wind turbulence and desired transient response characteristics. Design techniques include proper choosing of design versus evaluation models, choosing appropriate performance index responses, and use of classical evaluation techniques. Results are obtained through a combination of frequency response shaping and gust observation. Effects of control rate and authority saturation are examined with a new rapid

calculation of random input describing functions. Parameter sensitivity is also evaluated using a Liapunov type matrix equation (Author)

**A76-41469 # Optimal path precision terrain following system** J E Funk (USAF, Development Planning Aeronautical Systems Div., Wright-Patterson AFB, Ohio). In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings. New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 383-390. 11 refs. (AIAA 76-1958)

A new approach to the informational processing in a terrain following control system uses a cubic-spline curve to provide a very smooth reference path for the aircraft to follow. The spline is optimally computed to lie as close as possible to the terrain and yet to satisfy the practical constraints. Since the computed optimal path is smoother than those of other systems, the path and its derivatives can be used in a simple tracking system to provide precise control over the aircraft path. The scheme has onboard potential for advanced terrain-following systems, since splines allow consideration of fewer computational data points (Author)

**A76-41470 \* # Guidance logic for spiral approaches** W M Hollister (MIT, Cambridge, Mass.) and W C Hoffman (Aerospace Systems, Inc., Burlington, Mass.). In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings. New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 391-399. Contract No. NAS1 12199 (AIAA 76-1959)

A spiral approach concept is proposed as a standard procedure for independent, commercial VTOL operations conducted in close proximity to CTOL operations. A guidance logic is developed for this VTOL application, although the results may be applicable to curved approaches by STOL or CTOL aircraft as well. The guidance concept attempts to maintain constant airspeed along a fixed radius nominal spiral. The presence of wind requires a continuous variation in bank angle and heading rate to remain on the desired path. Linear perturbation analysis is used to select satisfactory feedback gains for commanded bank angle, longitudinal acceleration and vertical speed. A wind estimator detects differences between the predicted and observed wind and uses the result to modify the nominal control. For 4-D guidance the nominal time must be computed as a function of turn angle, which requires the solution of an elliptic integral. Time-varying longitudinal accelerations are necessary for 4-D guidance when the observed wind differs from the predicted wind, or when wind shear is present. The logic and the linear feedback gains have been tested in a nonlinear simulation. Results have generally verified the performance predicted by linear analysis (Author)

**A76-41480 \* # Stability and control of maneuvering high-performance aircraft** R F Stengel and P W Berry (Analytic Sciences Corp., Reading, Mass.). In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings. New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p. 485-492. Contract No. NAS1 13618 (AIAA 76-1973)

Stability and control characteristics of a high-performance aircraft have been examined over a wide range of maneuvering flight conditions, in order to identify general rules for the design of departure preventing control systems. This has been accomplished using fully coupled linear dynamic models which account for nonzero mean values of aerodynamic angles and angular rates. Stability augmentation systems derived from optimal control theory are shown to maintain stable, well-damped aircraft dynamics over a wide range of maneuvering flight conditions. This design approach generates cross feeds and control interconnects (as well as conventional feedback terms) for improved aircraft stability (Author)

**A76-41481 \* # A comparison of digital flight control design methods** J D Powell, E Parsons (Stanford University, Stanford, Calif.), and M G Tashker (Stanford Research Institute, Menlo Park,

Calif.) In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 493-501 19 refs Grant No. NSG 1137 (AIAA 76 1975)

Many variations in design methods for aircraft digital flight control have been proposed in the literature. In general, the methods fall into two categories: those where the design is done in the continuous domain (or s plane), and those where the design is done in the discrete domain (or z plane). This paper evaluates several variations of each category and compares them for various flight control modes of the Langley TCV Boeing 737 aircraft. Design method fidelity is evaluated by examining closed loop root movement and the frequency response of the discretely controlled continuous aircraft. It was found that all methods provided acceptable performance for sample rates greater than 10 cps except the 'uncompensated s-plane design' method which was acceptable above 20 cps. A design procedure based on optimal control methods was proposed that provided the best fidelity at very slow sample rates and required no design iterations for changing sample rates.

(Author)

**A76-41482 \* #** Dual redundant sensor FDI techniques applied to the NASA F8C DFBW aircraft. M. N. Desai, J. C. Deckert, J. J. Deyst, A. S. Willsky, and E. Y. Chow (Charles Stark Draper Laboratory, Inc., Cambridge, Mass.) In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 502-513 6 refs Contract No. NAS1-13914 (AIAA 76 1976)

An onboard failure detection and identification (FDI) technique for dual redundant sensors on the NASA F8C digital fly-by-wire (DFBW) aircraft is presented. The failure of one of a pair of sensors of the same type is detected by a direct redundancy trigger which observes the difference between the outputs of these two sensors. Identification of the failed sensor is accomplished utilizing the analytic redundancy that exists as kinematic and functional relationships among the variables being measured by dissimilar instruments. In addition, identification of generic failures, common to both instruments of a given type, is accomplished by using a time trigger to periodically initiate analytic redundancy failure identification tests for individual sensors. The basic form of these tests is the comparison of the measurement of a variable using the suspect instrument with another measurement of the same variable obtained using other instrument types.

(Author)

**A76-41485 #** Analysis of optimal evasive maneuvers based on a linearized two-dimensional kinematic model. J. Shinar and D. Steinberg (Technion - Israel Institute of Technology, Haifa, Israel). In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 546-554 15 refs (AIAA 76 1979)

Optimal evasion from homing missiles is analyzed assuming 2-D linearized kinematics. Instead of solving two point boundary value problems, simple search technique is used. The simplicity of this approach enables factors frequently neglected in analytical studies to be considered including exact system dynamics structure, location of saturation elements, limited evader roll rate, etc. Validity of analysis is limited, but not more than of nonlinear 2-D models, to nearly 'head on' or 'tail chase' situations. Engagements with other initial conditions require 3-D modeling. The method presented in this paper can be extended for such 3-D analysis.

(Author)

**A76-41486 \* #** Omega navigation for general aviation. W. M. Hollister (MIT, Cambridge, Mass.) In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 575-580 6 refs Grant No. NGL 22-009-640 (AIAA 76-1987)

A 70-hour flight test evaluation of an Omega navigation system was performed using a Piper Cherokee 180, to determine the feasibility of Omega for worldwide general aviation navigation. Measurements were made of position accuracy, noise phenomena, and signal to noise ratio. It was found that Omega accuracy is essentially insensitive to local geography, but that there are isolated local interference phenomena associated with radio transmitters, although the strongest noise source observed was due to the onboard power source for the VHF comm/nav radio. An occurrence of lane jumps was observed when attempting to navigate with one weak station.

B. J.

**A76-41488 \* #** Development of a fluidic rudder. C. A. Belsterling (Franklin Institute Research Laboratories, Philadelphia, Pa.) In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 593-597 Contracts No. NAS1 13930, No. NAS1 12451 (AIAA 76 1990)

Wind tunnel tests were performed to examine the concept of aircraft controls without moving parts, and aircraft stabilization by means of scoop-fed slots. Results of wind tunnel tests, in the framework of a NASA program, to determine the force control characteristics of a symmetrical airfoil with scoop-fed slots are discussed. Further tests showed that a fluidic amplifier could be built into the airfoil and operate with ram air. A fluidic rudder was then developed, consisting of cascaded fluidic amplifiers necessary to couple low-level fluidic sensors with slot flow control of the aerodynamic force on the vertical tail.

B. J.

**A76-41489 \* #** Flight test evaluation of a separate surface attitude command control system on a Beech 99 airplane. S. W. Gee (NASA, Flight Research Center, Edwards, Calif.), G. E. Jenks, J. Roskam (Kansas, University, Lawrence, Kan.), and R. L. Stone (Beech Aircraft Corp., Wichita, Kan.) In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 598-609 14 refs (AIAA 76-1991)

A joint NASA/university/industry program was conducted to flight evaluate a potentially low cost separate surface implementation of attitude command in a Beech 99 airplane. Saturation of the separate surfaces was the primary cause of many problems during development. Six experienced professional pilots made simulated instrument flight evaluations in light to moderate turbulence. They were favorably impressed with the system, particularly with the elimination of control force transients that accompanied configuration changes. For ride quality, quantitative data showed that the attitude command control system resulted in all cases of airplane motion being removed from the uncomfortable ride region.

(Author)

**A76 41490 \* #** Flight evaluation of advanced navigation techniques for general aviation using frequency scanning. C. T. Jackson, Jr., D. G. Denery (NASA, Ames Research Center, Moffett Field, Calif.), A. J. Korsak, and B. Conrad (Stanford Research Institute, Menlo Park, Calif.) In Guidance and Control Conference, San Diego, Calif., August 16-18, 1976, Proceedings New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 610-619 (AIAA 76-1992)

Experiments on an automatic multisensor navigation concept are being conducted in a Cessna 402B. The test system consists of VOR, DME, and air data sensors controlled by a Hewlett Packard 9820A electronic calculator which processes the data and, by means of a four state Kalman filter, outputs position and ground and wind velocities to a map display. Novel features which make such a system potentially low-cost include frequency scanning operation of a single

## **A76-41491**

VOR receiver and a single DME transceiver and use of a shed vortex true airspeed sensor. Results obtained during flight in a local area where six to eight DME NAVAIDS were receivable yielded better than 1/4-mile accuracy (Author)

**A76-41491 \* #** Design and test experience with a triply redundant digital fly-by-wire control system K J Szalai (NASA, Flight Research Center, Edwards, Calif ), P G Felleman (Charles Stark Draper Laboratory, Inc , Cambridge, Mass ), J Gera (NASA, Langley Research Center, Hampton, Va ), and R D Glover (NASA, Johnson Space Center, Houston, Tex ) In Guidance and Control Conference, San Diego, Calif , August 16 18, 1976, Proceedings Conference sponsored by the American Institute of Aeronautics and Astronautics New York, American Institute of Aeronautics and Astronautics, Inc , 1976 30 p 21 refs (AIAA 76 1911)

A triplex digital fly by wire flight control system was developed and then installed in a NASA F-8C aircraft to provide fail-operative, full authority control. Hardware and software redundancy management techniques were designed to detect and identify failures in the system. Control functions typical of those projected for future actively controlled vehicles were implemented. This paper describes the principal design features of the system, the implementation of computer, sensor, and actuator redundancy management, and the ground test results. An automated test program to verify sensor redundancy management software is also described (Author)

**A76-41492 #** Experience with digital flight control systems J T Gallagher and I Saworotnow (Northrop Corp , Hawthorne, Calif ) In Guidance and Control Conference, San Diego, Calif , August 16 18, 1976, Proceedings Conference sponsored by the American Institute of Aeronautics and Astronautics New York, American Institute of Aeronautics and Astronautics, Inc , 1976 11 p (AIAA 76-1914)

The application of digital techniques to flight controls is discussed from a user's point of view. A core memory computer was used in a single channel fly-by-wire mode with a mechanical backup system on the NASA X-14B VTOL aircraft. A semiconductor memory digital air data computer was used as a major element in the flight control system for the USAF/Northrop YF 17 aircraft. Both applications were flight tested successfully. The work with single channel computers was expanded into multichannel applications using the Northrop Advanced Fighter Flight Control Test Stand for evaluation and investigation. Dual channel asynchronous operation of the MK-175 computer was investigated for failure monitoring and failure management techniques. Dual channel synchronous operation of the HDC 301 computer was similarly evaluated (Author)

## STAR ENTRIES

**N76-28155#** Committee on Science and Technology (U S House)

### THE FUTURE OF AVIATION, VOLUME 2

Washington GPO Jul 1976 553 p refs Papers for Subcomm on Aviation and Transportation R and D of Comm on Sci and Technol 94th Congr 2d Sess Jul 1976 (GPO-72-601) Avail SOD HC \$4 60

A comprehensive examination of the Future of Aviation was conducted in order to lay the basis for a national civil aviation research and development policy and in doing so to make a useful contribution to national transportation policy In addition to 8 days of hearings a number of invited papers were also solicited by the subcommittee and are included Author

**N76-28158\*#** National Aeronautics and Space Administration Langley Research Center Langley Station Va

### GEARED-ELEVATOR FLUTTER STUDY

Charles L Ruhlman Robert V Doggett Jr and Richard A Gregory (Boeing Commercial Airplane Co Seattle) May 1976 12 p refs Presented at AIAA/ASME/SAE 17th Struct Structural Dyn and Mater Conf Valley Forge Pa 5-7 May 1976 (NASA-TM-X-73902) Avail NTIS HC \$3 50 CSCL 01A

An experimental and analytical study was made of the transonic flutter characteristics of a supersonic transport tail assembly model having an all-movable horizontal tail with a geared elevator Two model configurations, namely one with a geared-elevator (2 8 to 1 0 gear ratio) and one with locked-elevator (1 0 to 1 0 gear ratio) were flutter tested in the Langley transonic dynamics tunnel with an empennage cantilever-mounted on a sting The geared-elevator configuration fluttered experimentally at about 20% higher dynamic pressures than the locked-elevator configuration The experimental flutter dynamic pressure boundaries for both configurations were nearly flat over a Mach number range from 0 9 to 1 1 Flutter calculations (mathematical models) were made for the geared-elevator configuration using three subsonic lifting-surface methods In one method the elevator was treated as a discrete surface and in the other two methods the stabilizer and elevator were treated as a single warped-surface with the primary difference between these two methods being in the mathematical implementation used A comparison of the experimental and analytical results shows that the discrete-elevator method predicted best the experimental flutter dynamic pressure level However the single warped-surface methods predicts more closely the experimental flutter frequencies and Mach number trends Author

**N76-28159\*#** National Aeronautics and Space Administration Langley Research Center Langley Station Va

### STATIC FORCE TESTS OF A SHARP LEADING EDGE DELTA-WING MODEL AT AMBIENT AND CRYOGENIC TEMPERATURES WITH A DESCRIPTION OF THE APPARATUS EMPLOYED

Robert A Kilgore and Edwin E Davenport Jun 1976 50 p refs (NASA-TM-X-73901) Avail NTIS HC \$4 00 CSCL 01A

A sharp leading edge delta-wing model was tested through an angle-of-attack range at Mach numbers of 0 75 0 80 and 0 85 at both ambient and cryogenic temperatures in the Langley 1/3-meter transonic cryogenic tunnel Total pressure was varied with total temperature in order to hold test Reynolds number constant at a given Mach number Agreement between the aerodynamic data obtained at ambient and cryogenic temperatures indicates that flows with leading-edge vortex effects are duplicated

properly at cryogenic temperatures The test results demonstrate that accurate aerodynamic data can be obtained by using conventional force-testing techniques if suitable measures are taken to minimize temperature gradients across the balance and to keep the balance at ambient (warm) temperatures during cryogenic operation of the tunnel Author

**N76-28160\*#** National Aeronautics and Space Administration Langley Research Center Langley Station Va

### AERODYNAMIC CHARACTERISTICS OF A 1/6-SCALE MODEL OF THE ROTOR SYSTEMS RESEARCH AIRCRAFT WITH THE ROTORS REMOVED

Raymond E Mineck Carl R Freeman and James L Hassell Jr Washington NASA Jul 1976 191 p refs (NASA-TN-D-8198 L-10435) Avail NTIS HC \$7 50 CSCL 01A

A wind-tunnel investigation was conducted to refine the aerodynamic characteristics of the rotor systems research aircraft For the investigation a 1/6-scale model without a main rotor or a tail rotor was used The model provided the capability for testing different engine nacelle sizes, engine pylon fairings and tail configurations The engine thrust effects were modeled by small engine simulators (fans) Data were obtained primarily over an angle-of-attack range from -13 deg to 13 deg at several values of sideslip Stability characteristics and control effectiveness were investigated The model with the scaled engine nacelles and the combination T-tail and lower horizontal tail displayed longitudinal and lateral-directional stability Results show that by reducing the horizontal or vertical-tail span the longitudinal stability is decreased Reducing the engine nacelle size increases the static stability of the model Effective dihedral is essentially zero at 0 deg angle of attack and 0 deg wing incidence Author

**N76-28161\*#** Boeing Commercial Airplane Co Seattle Wash A COMPUTATIONAL SYSTEM FOR AERODYNAMIC DESIGN AND ANALYSIS OF SUPERSONIC AIRCRAFT PART 1 GENERAL DESCRIPTION AND THEORETICAL DEVELOPMENT Final Report

W D Middleton and J L Lundry Washington NASA Jul 1976 83 p refs Parts 1, 2 and 3 of this series supersede NASA-CR-2520, NASA-CR-2521 and NASA-CR-2522 (Contract NAS1-13732)

(NASA-CR-2715 D6-43798-1-Pt-1) Avail NTIS HC \$5 00 CSCL 01A

An integrated system of computer programs was developed for the design and analysis of supersonic configurations The system uses linearized theory methods for the calculation of surface pressures and supersonic area rule concepts in combination with linearized theory for calculation of aerodynamic force coefficients Interactive graphics are optional at the user's request Schematics of the program structure and the individual overlays and subroutines are described Author

**N76-28162\*#** Boeing Commercial Airplane Co Seattle Wash A COMPUTATIONAL SYSTEM FOR AERODYNAMIC DESIGN AND ANALYSIS OF SUPERSONIC AIRCRAFT PART 3 COMPUTER PROGRAM DESCRIPTION Final Report

W D Middleton J L Lundry and R G Coleman Washington NASA Jul 1976 110 p Parts 1, 2 and 3 of this series supersede NASA-CR-2520, NASA-CR-2521 and NASA-CR-2522

(Contract NAS1-13732) (NASA-CR-2717 D6-43798-3-Pt-3) Avail NTIS HC \$5 50 CSCL 01A

For abstract see part 1

**N76-28163\*#** National Aeronautics and Space Administration Langley Research Center, Langley Station, Va

### VORTEX-LATTICE UTILIZATION

Washington 1976 409 p refs Workshop held at Hampton, Va 17-18 May 1976

(NASA-SP-405 L-10948) Avail NTIS HC \$11 00 CSCL 01A

The many novel innovative, and unique implementations and applications of the vortex-lattice method to aerodynamic design

and analysis which have been performed by Industry, Government, and Universities were presented. Although this analytical tool is not new it continues to be utilized and refined in the aeronautical community.

**N76-28165\*** National Aeronautics and Space Administration  
Langley Research Center, Langley Station, Va  
**SUBSONIC FINITE ELEMENTS FOR WING BODY COMBINATIONS**

James L Thomas / *In its Vortex-Lattice Utilization* 1976 p 11-26  
refs  
CSCL 01A

Capabilities, limitations, and applications of various theories for the prediction of wing-body aerodynamics are reviewed. The methods range from approximate planar representations applicable in preliminary design to surface singularity approaches applicable in the later stages of detail design. The available methods for three-dimensional configurations are limited as inviscid methods with viscous effects included on an empirical or strip basis.

Author

**N76-28167\*** Lockheed-Georgia Co., Marietta  
**NUMERICAL METHOD TO CALCULATE THE INDUCED DRAG OR OPTIMUM LOADING FOR ARBITRARY NON-PLANAR AIRCRAFT**

James A Blackwell, Jr / *In NASA Langley Res Center Vortex-Lattice Utilization* 1976 p 49-70 refs

CSCL 01A

A simple unified numerical method applicable to non-planar subsonic aircraft has been developed for calculating either the induced drag for an arbitrary loading or the optimum aircraft loading which results in minimum induced drag. The method utilizes a vortex lattice representation of the aircraft lifting surfaces coupled with the classic equations and theorems for computing and minimizing induced drag. Correlation of results from the numerical method with non-planar solutions obtained from other more complex theories indicates very good agreement. Comparison of the induced-drag computations using the numerical method with experimental data for planar and non-planar configurations was also very good.

Author

**N76-28168\*** Boeing Co., Seattle, Wash  
**OPTIMIZATION AND DESIGN OF THREE-DIMENSIONAL AERODYNAMIC CONFIGURATIONS OF ARBITRARY SHAPE BY A VORTEX LATTICE METHOD**

Winfried M Feifel / *In NASA Langley Res Center Vortex-Lattice Utilization* 1976 p 71-88 refs

CSCL 01A

A new method based on vortex lattice theory has been developed which can be applied to the combined analysis, induced drag optimization, and aerodynamic design of three-dimensional configurations of arbitrary shape. Geometric and aerodynamic constraints can be imposed on both the optimization and the design process. The method is compared with several known analytical solutions and is applied to several different design and optimization problems, including formation flight and wingtip fins for the Boeing KC-135 tanker airplane. Good agreement has been observed between the theoretical predictions and the wind tunnel test results for the KC-135 modification.

Author

**N76-28169\*** National Aeronautics and Space Administration  
Langley Research Center, Langley Station, Va  
**MINIMUM TRIM DRAG DESIGN FOR INTERFERING LIFTING SURFACES USING VORTEX-LATTICE METHODOLOGY**

John E Lamar / *In its Vortex-Lattice Utilization* 1976 p 89-111 refs

CSCL 01A

A new method has been developed by which the mean camber surface can be determined for trimmed noncoplanar planforms with minimum vortex drag under subsonic conditions. The method uses a vortex lattice and overcomes previous

difficulties with chord loading specification. It uses a Trefftz plane analysis to determine the optimum span loading for minimum drag, then solves for the mean camber surface of the wing which will provide the required loading. Pitching-moment or root-bending-moment constraints can be employed as well as the design lift coefficient. Sensitivity studies of vortex-lattice arrangement have been made with this method and are presented. Comparisons with other theories show generally good agreement. The versatility of the method is demonstrated by applying it to (1) isolated wings, (2) wing-canard configurations, (3) a tandem wing, and (4) a wing-winglet configuration.

Author

**N76-28170\*** National Aeronautics and Space Administration  
Langley Research Center, Langley Station, Va  
**APPLICATIONS OF VORTEX LATTICE THEORY TO PRELIMINARY AERODYNAMIC DESIGN**

John W Paulson Jr / *In its Vortex-Lattice Utilization* 1976 p 113-126 refs  
CSCL 01A

Some applications of the vortex-lattice theory to the preliminary aerodynamic design and analysis of subsonic aircraft were presented. These methods include the Rockwell-Tulinius vortex-lattice theory for estimating aerodynamic characteristics, a Trefftz plane optimization procedure for determining the span loads for minimum induced drag, and a modification of the Trefftz plane procedure to estimate the induced drag for specified span loads. The first two methods are used to aerodynamically design aircraft planforms, twists, and cambers, and the latter method is used to estimate the drag for components such as flaps and control surfaces. Results from the theories for predicting lift and pitching moment, drag due to lift, and the drag of control surfaces are compared with experimental data. This data was obtained on a general aviation model with flaps and a close-coupled canard-wing model.

Author

**N76-28174\*** Kansas Univ., Lawrence  
**UPPER-SURFACE-BLOWING JET WING INTERACTION**  
C Edward Lan / *In NASA Langley Res Center Vortex-Lattice Utilization* 1976 p 187-198 refs

(Grant NsG-1139)

CSCL 01A

A linear inviscid subsonic compressible flow theory is formulated for predicting the aerodynamic characteristics of upper-surface-blowing configurations. The effect of the thick jet is represented by a two-vortex-sheet model in order to account for the Mach number nonuniformity. The wing loading with the jet interaction effects is computed by satisfying boundary conditions on the wing and the jet surfaces. The vortex model is discussed in detail.

Author

**N76-28175\*** Nielsen Engineering and Research, Inc., Mountain View, Calif  
**CALCULATION OF THE LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF WING-FLAP CONFIGURATIONS WITH EXTERNALLY BLOWN FLAPS**

Michael R Mendenhall / *In NASA Langley Res Center Vortex-Lattice Utilization* 1976 p 199-218 refs

(Contract NAS1-13158)

CSCL 01A

An analytical method for predicting the longitudinal aerodynamic characteristics of externally blown flap configurations is described. Two potential flow models make up the prediction method: a wing and flap lifting-surface model and a turboban engine wake model. A vortex-lattice lifting-surface method is used to represent the wing and multiple-slotted trailing-edge flaps. The jet wake is represented by a series of closely spaced vortex rings normal to a centerline which is free to move to conform to the local flow field. The two potential models are combined in an iterative fashion to predict the jet wake interference effects on a typical EBF configuration. Comparisons of measured and predicted span-load distributions, individual surface forces, and moments on the complete configuration and flow fields are included.

Author

**N76-28176\*** National Aeronautics and Space Administration  
Langley Research Center Langley Station Va  
**SOME RECENT APPLICATIONS OF THE SUCTION  
ANALOGY TO ASYMMETRIC FLOW SITUATIONS**

James M Luckring /In its Vortex-Lattice Utilization 1976  
p 219-236 refs  
CSCL 01A

A recent extension of the suction analogy for the estimation of vortex loads on asymmetric configurations was reviewed. This includes the asymmetric augmented vortex lift and the forward sweep effect on side edge suction. Application of this extension to a series of skewed wings has resulted in an improved estimating capability for a wide range of asymmetric flow situations. Hence the suction analogy concept now has more general applicability for subsonic lifting surface analysis. Author

**N76-28177\*** General Dynamics/Fort Worth Tex  
**APPLICATION OF THE VORTEX-LATTICE TECHNIQUE TO  
THE ANALYSIS OF THIN WINGS WITH VORTEX SEPARATION  
AND THICK MULTI-ELEMENT WINGS**

Charles W Smith and Ishwar C Bhateley /In NASA Langley  
Res Center Vortex-Lattice Utilization 1976 p 237-260 refs

CSCL 01A

Two techniques for extending the range of applicability of the basic vortex-lattice method are discussed. The first improves the computation of aerodynamic forces on thin low-aspect-ratio wings of arbitrary planforms at subsonic Mach numbers by including the effects of leading-edge and tip vortex separation characteristic of this type wing through use of the well-known suction-analogy method of E C Polhamus. Comparisons with experimental data for a variety of planforms are presented. The second consists of the use of the vortex-lattice method to predict pressure distributions over thick multi-element wings (wings with leading- and trailing-edge devices). A method of laying out the lattice is described which gives accurate pressures on the top and part of the bottom surface of the wing. Limited comparisons between the result predicted by this method, the conventional lattice arrangement method, experimental data, and 2-D potential flow analysis techniques are presented. Author

**N76-28178\*** McDonnell Aircraft Co St Louis Mo  
**COMPARISON OF VORTEX LATTICE PREDICTED FORCES  
WITH WIND TUNNEL EXPERIMENTS FOR THE F-4E(CCV)  
AIRPLANE WITH A CLOSELY COUPLED CANARD**

Lloyd W Gross /In NASA Langley Res Center Vortex-Lattice  
Utilization 1976 p 261-283 refs

CSCL 01A

The F-4E (CCV) wind tunnel model with closely coupled canard control surfaces was analyzed by means of a version of a vortex lattice program that included the effects of nonlinear leading edge or side edge vortex lift on as many as four individual planforms. The results were compared with experimental data from wind tunnel tests of a 5% scale model tested at a Mach number  $M = 0.6$ . They indicated that a nonlinear vortex lift developed on the side edges due to tip vortices, but did not appear to develop on the leading edges within the range of angles of attack that were studied. Instead, substantial leading edge thrust was developed on the lifting surfaces. A configuration buildup illustrated the mutual interference between the wing and control surfaces. On the configuration studied, addition of the wing increased the loading on the canard, but the additional load on the canard due to adding the stabilator was small. Author

**N76-28179\*** Virginia Polytechnic Inst and State Univ  
Blacksburg

**NEW CONVERGENCE CRITERIA FOR THE VORTEX-  
LATTICE MODELS OF THE LEADING-EDGE SEPARATION**

Osama A Kandil, Dean T Mook, and Ali H Nayfeh /In NASA  
Langley Res Center Vortex-Lattice Utilization 1976 p 285-300  
refs

(Grant NsG-1262)

CSCL 01A

The convergence criterion for the vortex-lattice technique which deals with delta wings exhibiting significant leading-edge separation was studied. It was shown that one can predict pressure distributions without irregularities which agree fairly well with experimental data (which show some irregularities of their own) by replacing the system of discrete vortex lines with a single concentrated core. This core has a circulation equal to the algebraic sum of the circulations around the discrete lines and is located at the centroid of these lines. Moreover, there is a requirement that the position and strength of the core must converge as the number of elements increases. Because the calculation of the position and strength of the core is much less involved than the calculation of the loads, this approach has the additional desirable feature of requiring less computational time. Author

**N76-28180\*** North Carolina State Univ Raleigh

**ARRANGEMENT OF VORTEX LATTICES**

Fred R DeJarnette /In NASA Langley Res Center Vortex-Lattice  
Utilization 1976 p 301-323 refs

(Grant DAAG29-76-G-0045)

CSCL 01A

A new method is developed for solving the lifting-surface equation for thin wings. The solution requires the downwash equation to be in the form of Cauchy integrals which can be interpreted as a vortex lattice with the positions of the vortices and control points dictated by the finite sum used to approximate the integrals involved. Lan's continuous loading method is employed for the chordwise integral since it properly accounts for the leading-edge singularity, Cauchy singularity, and Kutta condition. Unlike Lan, the spanwise loading is also continuous and the Cauchy singularity in the spanwise integral is also properly accounted for by using the midpoint trapezoidal rule and the theory of Chebyshev polynomials. This technique yields the exact classical solution to Prandtl's lifting-line equation. The solution to the lifting-surface equation for rectangular wings was found to compare well with other continuous loading methods, but with much smaller computational times and to converge faster than other vortex lattice methods. Author

**N76-28181\*** Vought Corp Hampton Va Advanced Technology  
Center

**LATTICE ARRANGEMENTS FOR RAPID CONVERGENCE**

Gary R Hough /In NASA Langley Res Center Vortex-Lattice  
Utilization 1976 p 325-342 refs

CSCL 01A

A simple systematic optimized vortex-lattice approach is developed for application to lifting-surface problems. It affords a significant reduction in computational costs when compared to current methods. Extensive numerical experiments have been carried out on a wide variety of configurations, including wings with camber and single or multiple flaps, as well as high-lift jetflap systems. Rapid convergence as the number of spanwise or chordwise lattices are increased is assured along with accurate answers. The results from this model should be useful not only in preliminary aircraft design but also for example as input for wake vortex roll-up studies and transonic flow calculations. Author

**N76-28182\*** Vought Corp Hampton Va  
**OPTIMUM LATTICE ARRANGEMENT DEVELOPED FROM  
A RIGOROUS ANALYTICAL BASIS**

John Deyoung /In NASA Langley Res Center Vortex-Lattice  
Utilization 1976 p 343-368 refs

(Contract NAS1-13500)

CSCL 01A

The spanwise vortex-lattice arrangement is mathematically established by lattice solutions of the slender wing which are shown to be analogous to the chordwise vortex-lattice thin wing solution. Solutions for any number  $N$  of panels wing theory lift and induced drag and thin wing theory lift and moment are predicted exactly. As  $N$  approaches infinity, the slender wing elliptic spanwise loading and thin wing cotangent chordwise

loading are predicted which proves there is mathematical convergence of the vortex-lattice method to the exact answer. Based on this planform spanwise lattice arrangement an A-vortex-lattice spanwise system is developed for an arbitrary aspect ratio A. This A-lattice has the optimum characteristic of predicting lift accurately for any value of N. Author

**N76-28184\*** Kansas Univ Lawrence  
**SOME APPLICATIONS OF THE QUASI VORTEX-LATTICE METHOD IN STEADY AND UNSTEADY AERODYNAMICS**  
 C Edward Lan In NASA Langley Res Center Vortex-Lattice Utilization 1976 p 385-406 refs

CSCL 01A

The quasi vortex-lattice method is reviewed and applied to the evaluation of backwash with applications to ground effect analysis. It is also extended to unsteady aerodynamics with particular interest in the calculation of unsteady leading-edge suction. Some applications in ornithopter aerodynamics are given. Author

**N76-28185\*** Virginia Polytechnic Inst and State Univ Blacksburg  
**UNSTEADY FLOW PAST WINGS HAVING SHARP-EDGE SEPARATION**  
 E H Atta, O A Kandil, D T Mook and A H Nayfeh In NASA Langley Res Center Vortex-Lattice Utilization 1976 p 407-421 ref  
 CSCL 01A

A vortex-lattice technique is developed to model unsteady incompressible flow past thin wings. This technique predicts the shape of the wake as a function of time, thus it is not restricted by planform aspect ratio, or angle of attack as long as vortex bursting does not occur and the flow does not separate from the wing surface. Moreover, the technique can be applied to wings of arbitrary curvature undergoing general motion, thus it can treat rigid-body motion, arbitrary wing deformation, gusts in the freestream, and periodic motions. Numerical results are presented for low-aspect rectangular wings undergoing a constant-rate rigid-body rotation about the trailing-edge. The results for the unsteady motion are compared with those predicted by assuming quasi-steady motion. The present results exhibit hysteretic behavior. Author

**N76-28186\*** National Aeronautics and Space Administration Langley Research Center Langley Station Va  
**SAMPLE WINGS FOR STUDY**  
 John E Lamar In its Vortex-Lattice Utilization 1976 p 423-424 refs  
 CSCL 01A

Two simple wings were selected for study using the various implementations (old and new) of the vortex lattice method. These are: (1) a rectangular wing with an aspect ratio of 2 and (2) a tapered wing with an aspect ratio of 5, a taper ratio of 0.5, a leading sweep of 3.317 deg, and a trailing edge sweep of 1.11308 deg. This was done in order to gain an appreciation for the accuracy of the various implementations. References were given where force, moment, and pressure data could be found for these wings. Y J A

**N76-28187\*#** National Aeronautics and Space Administration Ames Research Center Moffett Field Calif  
**NUMERICAL AIRFOIL OPTIMIZATION USING A REDUCED NUMBER OF DESIGN COORDINATES**  
 Garret N Vanderplaats and Raymond M Hicks Jul 1976 21 p refs  
 (NASA-TM-X-73151 A-6671) Avail NTIS HC \$3.50 CSCL 01A

A method is presented for numerical airfoil optimization whereby a reduced number of design coordinates are used to define the airfoil shape. The approach is to define the airfoil as a linear combination of shapes. These basic shapes may be analytically or numerically defined, allowing the designer to use his insight to propose candidate designs. The design problem

becomes one of determining the participation of each such function in defining the optimum airfoil. Examples are presented for two-dimensional airfoil design and are compared with previous results based on a polynomial representation of the airfoil shape. Four existing NACA airfoils are used as basic shapes. Solutions equivalent to previous results are achieved with a factor of more than 3 improvements in efficiency, while superior designs are demonstrated with an efficiency greater than 2 over previous methods. With this shape definition, the optimization process is shown to exploit the simplifying assumptions in the inviscid aerodynamic analysis used here, thus demonstrating the need to use more advanced aerodynamics for airfoil optimization. Author

**N76-28189\*#** National Aeronautics and Space Administration Langley Research Center, Langley Station Va  
**COMMENTS ON DIFFERENCE SCHEMES FOR THE THREE-DIMENSIONAL TRANSONIC SMALL-DISTURBANCE EQUATION FOR SWEEP WINGS**  
 Jerry C South Jr Jul 1976 10 p refs  
 (NASA-TM-X-71980) Avail NTIS HC \$3.50 CSCL 01A

Certain problems arise in constructing stable finite-difference schemes for the three-dimensional transonic small-disturbance equation with crossflow terms included to better approximate flows over swept wings. These problems are discussed and some possible remedies are offered. Author

**N76-28190\*#** Bell Helicopter Co Fort Worth Tex  
**WIND TUNNEL TEST RESULTS OF 25 FOOT TILT ROTOR DURING AUTOROTATION** Final Report  
 R L Marr 1 Feb 1976 91 p refs  
 (Contract NAS2-8580)  
 (NASA-CR-137824 Rept-301-099-005) Avail NTIS HC \$5.00 CSCL 01A

A 25 foot diameter tilt rotor was tested in the 40 by 80 foot large scale wind tunnel. The test confirmed the predicted autorotation capability of the XV-15 tilt rotor aircraft. Autorotations were made at 60, 80, and 100 knots. A limited evaluation of lateral cyclic was made. Test data indicate a minimum rate of descent of 2,200 feet per minute at 60 knots at the XV-15 design gross weight of 13,000 pounds. Author

**N76-28193\*#** Scientific Translation Service Santa Barbara Calif  
**APPLICATION OF THE MEASUREMENTS OF STATIC AND DYNAMIC AERODYNAMIC COEFFICIENTS FOR THE CALCULATED PREDICTION OF SPIN OBSERVED IN WIND TUNNELS**  
 M Vanmansart Washington NASA Aug 1976 18 p Transl into ENGLISH from the French report Presented at the SMP Specialists Meeting, Brussels 18-21 Nov 1975  
 (Contract NASw-2791)  
 (NASA-TT-F-17122) Avail NTIS HC \$3.50 CSCL 01A

The computational prediction of actual spin as an indispensable stage in the validation of a model for spin is described. Author

**N76-28194\*#** General Dynamics/Fort Worth, Tex  
**THE CALCULATION OF STEADY NON-LINEAR TRANSONIC FLOW OVER FINITE WINGS WITH LINEAR THEORY AERODYNAMICS**  
 Atlee M Cunningham, Jr Aug 1976 59 p refs  
 (Contract NAS1-13855)  
 (NASA-CR-145023) Avail NTIS HC \$4.50 CSCL 01A

The feasibility of calculating steady mean flow solutions for nonlinear transonic flow over finite wings with a linear theory aerodynamic computer program is studied. The methodology is based on independent solutions for upper and lower surface pressures that are coupled through the external flow fields. Two approaches for coupling the solutions are investigated which include the diaphragm and the edge singularity method. The final method is a combination of both where a line source along the wing leading edge is used to account for blunt nose airfoil effects, and the upper and lower surface flow fields are coupled through a diaphragm in the plane of the wing. An iterative



solution is used to arrive at the nonuniform flow solution for both nonlifting and lifting cases. Final results for a swept tapered wing in subcritical flow show that the method converges in three iterations and gives excellent agreement with experiment at  $\alpha = 0^\circ$  and  $2^\circ$ . Recommendations are made for development of a procedure for routine application. Author

**N76-28195#** Royal Aircraft Establishment Farnborough (England)

**MATHEMATICAL APPROACHES TO THE DYNAMICS OF DEFORMABLE AIRCRAFT**

1976 125 p refs. Supersedes RAE-TM-Struct-807, RAE-TR-71131-RAE-TR-71227

(ARC-R/M-3776-Mono, RAE-TM-Struct-807 RAE-TR-71131

RAE-TR-71227) Avail NTIS HC \$5.50, HMSO £ 7.70

Descriptions of two separate mathematical approaches to the dynamical problems of deformable aircraft are presented. The preface discusses the long-standing need for a philosophy to unify the work of stability and control specialists on the one hand and of flutter and gust response specialists on the other. Taylor attempts to satisfy the need by an extension to the deformable aircraft of concepts developed for the rigid aircraft in classical stability and control theory whereas Woodcock relies on an extension of ideas from the domain of flutter and gust response. A prolog to Taylor's contribution outlines the historical development of the subject while the main text of each paper is principally concerned with the setting up of the equations of motion and with the associated problems of the choice of frames of reference, the representation of the structural deformation and of the incremental aerodynamics, and the type of generalized coordinates to be employed.

**N76-28196** Royal Aircraft Establishment Farnborough (England)  
**THE MATHEMATICAL FOUNDATION FOR AN INTEGRATED APPROACH TO THE DYNAMICAL PROBLEMS OF DEFORMABLE AIRCRAFT**

A S Taylor. *In its* Math. Approaches to the Dyn of Deformable Aircraft 1976 p 5-76 refs

Equations of motion of a deformable aircraft in forms consistent with those of the rigid-aircraft equations of classical stability and control theory are developed. The derivation from the general equations, of separate sets of equations relating to equilibrium conditions and to perturbations therefrom is discussed. For the final development of the equations of perturbed (longitudinal) motion in scalar form a lumped-parameter representation of the aircraft, employing structural and aerodynamic influence coefficients, is assumed, and the formulation is in terms of the natural modes of the elastic airframe. It is shown how, by use of the 'residual flexibility' concept, the large-order system of equations which results from incorporating all the elastic modes dynamically, can be replaced by a lower-order system which involves only a few modes directly, but which takes account of the remainder by a modification of derivatives in the retained equations. The mathematical framework is used as the basis for a review of past concepts in the treatment of various aeroelastic problems. The limitations of the mathematical models are discussed and some suggestions are made regarding possible future developments. An outline of the historical development of the subject together with guide lines to the form of mathematical treatment best suited to current problems is given. Certain elements of the established mathematical framework for the investigation of rigid-aircraft dynamics are also presented. Author (ESA)

**N76-28197** Royal Aircraft Establishment, Farnborough (England)  
**THE DYNAMICS OF DEFORMABLE AIRCRAFT**

D L Woodcock. *In its* Math. Approaches to the Dyn of Deformable Aircraft 1976 p 77-123 refs

The choice of a way of formulating the equations of motion of a deformable aircraft is considered. Emphasis is placed on ease of understanding and application. It is suggested that the

use of a frame of reference moving with constant linear and angular velocity will often be the most convenient. In a few cases in order to obtain a linear problem, a formulation using body axes may be better and for this purpose body-fixed axes rather than mean-body axes are recommended. The relevant equations of motion are developed in detail. Author (ESA)

**N76-28198#** Naval Air Engineering Center, Lakehurst, NJ  
**AIRCRAFT CARRIER TURBULENCE STUDY FOR PREDICTING AIR FLOW DYNAMICS WITH INCREASING WIND-OVER-DECK VELOCITIES** Engineering Dept.

S Frost 28 Mar 1968 98 p refs

(AD-A020223, NAEC-ENG-7467) Avail NTIS CSCL 20/4

An intensive review of literature pertinent to aircraft carrier air flow dynamics and an evaluation of experiments were conducted in order to determine the effects of turbulence on landing aircraft. Particular emphasis was given to the effects on carrier aircraft operations which occur as a result of increasing wind-over-deck (WOD) velocities as well as carrier dynamics. The effects of WOD velocities and carrier dynamics on air boundary layer were also considered. Recommendations for future, more exacting data acquisition experiments, and theoretical studies are given. GRA

**N76-28202#** Aeronautical Research Associates of Princeton, Inc., NJ

**AN ANALYTIC AND EXPERIMENTAL INVESTIGATION OF THE WAKES BEHIND FLAPPED AND UNFLAPPED WINGS**  
Final Report

Alan J Bilanin, Coleman Donaldson and Richard S Snedeker  
Sep 1974 140 p refs

(Contract F33615-73-C-3138, AF Proj 1929)

(AD-A021344 AFFDL-TR-74-90) Avail NTIS CSCL 20/4

An analytic and experimental program was undertaken to define the near wake structure behind flapped and unflapped wings. The vortex wake structure is determined, given the wing lift and drag distributions with models developed in the spirit of Betz. A procedure to estimate the turbulent kinetic energy distribution in the vortex is also given as well as a method to determine discrete vortex positions in the downstream wake. GRA

**N76-28203\*#** United Technologies Research Center, East Hartford Conn

**COST/BENEFIT TRADE-OFFS FOR REDUCING THE ENERGY CONSUMPTION OF COMMERCIAL AIR TRANSPORTATION (RECAT)** Final Report

F W Gobetz and A P Dubin Jun 1976 200 p refs

(Contract NAS2-8608)

(NASA-CR-138877 UTRC-R76-912036-16) Avail NTIS HC \$7.50 CSCL 01C

A study has been performed to evaluate the opportunities for reducing the energy requirements of the US domestic air passenger transport system through improved operational techniques, modified in-service aircraft, derivatives of current production models, or new aircraft using either current or advanced technology. Each of the fuel-conserving alternatives has been investigated individually to test its potential for fuel conservation relative to a hypothetical baseline case in which current, in-production aircraft types are assumed to operate, without modification and with current operational techniques, into the future out to the year 2000. Author

**N76-28204\*#** United Technologies Research Center, East Hartford, Conn

**COST/BENEFIT TRADE-OFFS FOR REDUCING THE ENERGY CONSUMPTION OF COMMERCIAL AIR TRANSPORTATION (RECAT)** Summary Report

F W Gobetz and A A LeShane Jun 1976 43 p

(Contract NAS2-8608)

(NASA-CR-137878 UTRC-R76-912036-17) Avail NTIS HC \$4.00 CSCL 01C

The RECAT study evaluated the opportunities for reducing the energy requirements of the US domestic air passenger transport system through improved operational techniques.

modified in-service aircraft derivatives of current production models, or new aircraft using either current or advanced technology. Each of these fuel-conserving alternatives was investigated individually to test its potential for fuel conservation relative to a hypothetical baseline case in which current, in-production aircraft types are assumed to operate, without modification and with current operational techniques, into the future out to the year 2000. Consequently, while the RECAT results lend insight into the directions in which technology can best be pursued for improved air transport fuel economy, no single option studied in the RECAT program is indicative of a realistic future scenario. Author

**N76-28205#** Federal Aviation Agency Washington, D C Office of Systems Engineering Management  
**RATIONALE FOR IMPROVING THE PROTECTION AGAINST MID-AIR COLLISIONS VOLUME 1 SUMMARY**  
 David R Israel, Richard F Bock John L Brennan, Thomas M Johnston Gordon Jolitz Keith D McDonald, Owen E McIntire, Martin T Pozesky and John Reed Dec 1975 32 p refs  
 (AD-A023810/5G1 FAA-ED-75-1-Vol-1) Avail NTIS HC \$4 00 CSCL 01/2

The findings conclusions and recommendations are summarized of a Federal Aviation Administration working group established to consider the pertinent data, analyses, tests and other factors bearing on possible methods and techniques for preventing midair collisions. Supporting details and information developed by the working group are available in the form of a large number of self-explanatory briefing charts and tables which are contained in another volume. Author

**N76-28206\*#** National Aeronautics and Space Administration Ames Research Center, Moffett Field Calif  
**WAKE VORTEX ENCOUNTER HAZARDS CRITERIA FOR TWO AIRCRAFT CLASSES**  
 Robert I Sammonds Glen W Stinnett, Jr and William E Larsen (FAA Washington, D C) Jun 1976 40 p refs  
 (NASA-TM-X-73113 FAA-RD-75-206, A-6493) Avail NTIS HC \$4 00 CSCL 01C

An investigation was conducted using a piloted, motion-base simulator to determine wake vortex hazard criteria for two classes of jet transport aircraft. A light business jet and a large multiengine jet transport were represented respectively. The hazard boundaries were determined in terms of the maximum bank angle due to the vortex encounter. Upsets as small as 7 deg in bank angle were considered to be hazardous at breakout altitude (200 ft (61 0 m)) for Instrument Flight Rule (IFR) and at 50 ft (15 2 m) for Visual Flight Rule (VFR) for both aircraft classes. Proximity to the ground was the primary reason for a hazardous rating. This was reflected in the reduction in the maximum bank angle at the hazard boundary and in more consistent ratings as altitude was decreased. Author

**N76-28207\*#** Kanner (Leo) Associates, Redwood City, Calif  
**ERGONOMIC ASPECTS OF AIR ACCIDENTS DURING AGRICULTURAL SERVICE**  
 S Kwiatkowski Washington NASA Aug 1976 9 p Transl into ENGLISH of conf paper from the Institut Lotnictwa, Warsaw Presented at the 1st Nat Scientific-Technological Conf 17-19 Mar 1975, proceedings p 283-289  
 (Contract NASw-2790)  
 (NASA-TT-F-17146) Avail NTIS HC \$3 50 CSCL 01C

The chief shortcomings in the elements of agricultural aircraft are discussed along with the main causes of air accidents occurring during agricultural service based on some statistics on the frequency of the various causes. Some of these causes were found to be collisions with electric power lines, collisions with objects in the chemical loading area, hitting the ground during large turns, emergency landings due to lack of fuel, engine failure, and landing. The special problems of the pilot being adversely influenced by chemicals and noise are discussed, and the lack of satisfactory solutions is noted. Author

**N76-28208#** Civil Aeronautics Board, Washington, D C Statistical Data Div  
**HANDBOOK OF AIRLINE STATISTICS, 1975 SUPPLEMENT**

# **Final Report**

Jerold Coffee Nov 1975 223 p  
 (PB-250519/6 CAB-BAS-75-01-Suppl) HC \$7 75 CSCL 01B  
 An updated reference volume of some 216 pages includes a wide variety of annual traffic profit and loss and balance sheet data for each United States Certificated Air Carrier for 1973 and 1974. Other sections include chronologies of significant events affecting aviation -- in general, growth of the airline industry, significant legislation and decisions and technological advances as well as carrier group data for calendar 1973 and 1974. For the first time certain rather limited information involving classes of air carriers other than Certificated Air Carriers has been included. Author

**N76-28209#** National Transportation Safety Board, Washington D C Bureau of Aviation Safety  
**ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA, U S AIR CARRIER OPERATIONS 1974**  
 30 Dec 1975 97 p  
 (PB-250813/3, NTSB-ARC-76-1) Avail NTIS HC \$5 00 CSCL 01B

The publication presents the record of aviation accidents which occurred in all operations of the U S air carriers for calendar year 1974. It includes analyses by classes of carriers, causes and related factors, types of accidents and phases of operations. Statistical tables, which summarize the accidents, fatalities and accident rates, causal tables and briefs of accidents are presented. GRA

**N76-28210#** National Transportation Safety Board Washington D C Bureau of Aviation Safety  
**BRIEFS OF ACCIDENTS INVOLVING ALCOHOL AS A CAUSE/FACTOR, US GENERAL AVIATION 1974**  
 15 Dec 1975 44 p  
 (PB-250515/4, NTSB-AMM-75-17) Avail NTIS HC \$4 00 CSCL 01B

Reports are presented on all U S general aviation accidents occurring in 1974 involving alcohol impairment as a cause/factor. Included are 50 accident briefs, 46 of which involve fatal accidents. The brief format presents the facts, conditions, circumstances and probable cause(s)/factor(s) for each accident. Additional statistical information is tabulated by type of accident, phase of operation, injury index, aircraft damage, pilot certificate, injuries and causal factor(s). GRA

**N76-28218** Georgia Inst of Tech Atlanta  
**MINIMUM WEIGHT DESIGN OF FUSELAGE TYPE STIFFENED CIRCULAR CYLINDRICAL SHELLS SUBJECTED TO PURE TORSION AND COMBINED TORSION WITH AXIAL COMPRESSION WITH AND WITHOUT LATERAL PRESSURE** Ph D Thesis  
 Jagannath Giri 1976 164 p  
 Avail Univ Microfilms Order No 76-16281

A procedure including a highly automated computer program for the minimum weight design of fuselage type stiffened circular cylindrical shells subjected to torsion and to torsion combined with axial compression with and without lateral pressure is developed. For an internally stiffened fuselage type thin circular cylindrical shell of specified material, radius and length, the size, shape, spacings of stiffeners and the skin thickness are found in order that it can safely carry a prescribed pure torsion or combined torsion with axial compression with and without lateral pressure with minimum weight. The procedure is demonstrated through a number of selected practical design problems. Dissert Abstr

**N76-28219\*#** Lockheed-California Co Burbank  
**ARROW-WING SUPERSONIC CRUISE AIRCRAFT STRUCTURAL DESIGN CONCEPTS EVALUATION VOLUME 1 SECTIONS 1 THROUGH 6**  
 I F Sakata and G W Davis [1975] 436 p refs  
 (Contract NAS1-12288)  
 (NASA-CR-132575-1) Avail NTIS HC \$11 75 CSCL 01C

The structural approach best suited for the design of a Mach 2.7 arrow-wing supersonic cruise aircraft was investigated. Results, procedures and principal justification of results are

presented Detailed substantiation data are given In general each major analysis is presented sequentially in separate sections to provide continuity in the flow of the design concepts analysis effort In addition to the design concepts evaluation and the detailed engineering design analyses supporting tasks encompassing (1) the controls system development (2) the propulsion-airframe integration study, and (3) the advanced technology assessment are presented Author

**N76-28220\*# Lockheed-California Co , Burbank  
ARROW-WING SUPERSONIC CRUISE AIRCRAFT  
STRUCTURAL DESIGN CONCEPTS EVALUATION  
VOLUME 2. SECTIONS 7 THROUGH 11**

I F Sakata and G W Davis [1975] 409 p refs

(Contract NAS1-12288)

(NASA-CR-132575-2) Avail NTIS HC \$11 00 CSCL 01C

The materials and advanced producibility methods that offer potential structural mass savings in the design of the primary structure for a supersonic cruise aircraft are identified and reported A summary of the materials and fabrication techniques selected for this analytical effort is presented Both metallic and composite material systems were selected for application to a near-term start-of-design technology aircraft Selective reinforcement of the basic metallic structure was considered as the appropriate level of composite application for the near-term design Author

**N76-28221\*# Lockheed-California Co Burbank  
ARROW-WING SUPERSONIC CRUISE AIRCRAFT  
STRUCTURAL DESIGN CONCEPTS EVALUATION.  
VOLUME 3: SECTIONS 12 THROUGH 14**

I F Sakata and G W Davis [1975] 330 p refs

(Contract NAS1-12288)

(NASA-CR-132575-3) Avail NTIS HC \$10 00 CSCL 01C

The design of an economically viable supersonic cruise aircraft requires the lowest attainable structural-mass fraction commensurate with the selected near-term structural material technology To achieve this goal of minimum structural-mass fraction, various combinations of promising wing and fuselage primary structure were analyzed for the load-temperature environment applicable to the arrow wing configuration This analysis was conducted in accordance with the design criteria specified and included extensive use of computer-aided analytical methods to screen the candidate concepts and select the most promising concepts for the in-depth structural analysis Author

**N76-28222\*# Lockheed-California Co Burbank  
ARROW-WING SUPERSONIC CRUISE AIRCRAFT  
STRUCTURAL DESIGN CONCEPTS EVALUATION.  
VOLUME 4 SECTIONS 15 THROUGH 21**

I F Sakata and G W Davis [1975] 430 p refs

(Contract NAS1-12288)

(NASA-CR-132575-4) Avail NTIS HC \$11 75 CSCL 01C

The analyses performed to provide structural mass estimates for the arrow wing supersonic cruise aircraft are presented To realize the full potential for structural mass reduction a spectrum of approaches for the wing and fuselage primary structure design were investigated The objective was (1) to assess the relative merits of various structural arrangements concepts, and materials, (2) to select the structural approach best suited for the Mach 2.7 environment, and (3) to provide construction details and structural mass estimates based on in-depth structural design studies Production costs, propulsion-airframe integration and advanced technology assessment are included Author

**N76-28224\*# National Aeronautics and Space Administration  
Langley Research Center, Langley Station, Va  
STUDY OF OPERATIONAL PARAMETERS IMPACTING  
HELICOPTER FUEL CONSUMPTION**

Jeffrey L Cross and Darlene D Stevens Jul 1976 42 p refs (NASA-TM-X-73922) Avail NTIS HC \$4 00 CSCL 01C

A computerized study of operational parameters affecting helicopter fuel consumption was conducted as an integral part of the NASA Civil Helicopter Technology Program The study

utilized the Helicopter Sizing and Performance Computer Program (HESCOMP) developed by the Boeing-Vertol Company and NASA Ames Research Center An introduction to HESCOMP is incorporated in this report The results presented were calculated using the NASA CH-53 civil helicopter research aircraft specifications Plots from which optimum flight conditions for minimum fuel use that can be obtained are presented for this aircraft The results of the study are considered to be generally indicative of trends for all helicopters Author

**N76-28225\*# McDonnell-Douglas Corp , Long Beach, Calif  
TECHNICAL AND ECONOMIC ASSESSMENT OF SPAN-  
LOADED CARGO AIRCRAFT CONCEPTS**

Jan 1976 142 p

(Contract NAS1-13964)

(NASA-CR-144962) Avail NTIS HC \$6 00 CSCL 01C

The benefits are assessed of span distributed loading concepts as applied to future commercial air cargo operations A two phased program is used to perform this assessment The first phase consists of selected parametric studies to define significant configuration, performance, and economic trends The second phase consists of more detailed engineering design, analysis, and economic evaluations to define the technical and economic feasibility of a selected spanloader design A conventional all-cargo aircraft of comparable technology and size is used as a comparator system The technical feasibility is demonstrated of the spanloader concept with no new major technology efforts required to implement the system However certain high pay-off technologies such as winglets, airfoil design and advanced structural materials and manufacturing techniques need refinement and definition prior to application In addition further structural design analysis could establish the techniques and criteria necessary to fully capitalize upon the high degree of structural commonality and simplicity inherent in the spanloader concept Author

**N76-28226\*# Princeton Univ , NJ Dept of Aerospace and  
Mechanical Sciences**

**THE LONGITUDINAL EQUATIONS OF MOTION OF A TILT  
PROP/ROTOR AIRCRAFT INCLUDING THE EFFECTS OF  
WING AND PROP/ROTOR BLADE FLEXIBILITY**

H C Curtiss, Jr Apr 1976 63 p

(Grant NSG-2045)

(NASA-CR-137855 TR-1273) Avail NTIS HC \$4 50 CSCL 01C

The equations of motion for the longitudinal dynamics of a tilting prop/rotor aircraft are developed The analysis represents an extension of the equations of motion The effects of the longitudinal degrees of freedom of the body (pitch heave and horizontal velocity) are included The results of body freedom can be added to the equations of motion for the flexible wing propeller combination Author

**N76-28227\*# Lockheed-Georgia Co Marietta  
GROUND SIMULATION AND TUNNEL BLOCKAGE FOR A  
JET-FLAPPED, BASIC STOL MODEL TESTED TO VERY HIGH  
LIFT COEFFICIENTS**

J E Hackett, R A Boles, and D E Lilley Mar 1976 133 p refs

(Contract NAS2-8745)

(NASA-CR-137857) Avail NTIS HC \$6 00 CSCL 01C

Ground effects experiments and large/small-tunnel interference studies were carried out on a model with a 20-inch (50.8 cm) span wing The wing, which includes a highly deflected knee-blown flap can be fitted with unflapped tips and slats A low-mounted tailplane can be fitted to the aft fuselage Three-component balance measurements made with a fixed ground equipped with a single boundary-layer blowing slot, were compared with datum, moving-ground results Good comparisons were obtained up to model blowing momentum coefficients of approximately two after which the particular floor blowing settings used proved insufficient to prevent floor separation in the vicinity of the model Skin friction measurements taken routinely along the floor centerline proved invaluable during the analysis of results and their use is recommended as input to determination of

floor BLC setting A careful investigation was made of pitching moments, including tail-on, close-to-ground cases, with favorable results Drag proved the most sensitive to the change from a moving to the boundary-layer controlled ground Author

**N76-28229\*# Scientific Translation Service, Santa Barbara, Calif THE EFFECT OF ROCKETS AND DISSYMMETRIC LOADS ON THE SPIN, BY STATIC MOMENTS**

J Gobeltz and L Beaurain Washington NASA Aug 1976 31 p Transl into ENGLISH from the French report Presented at the SMP Specialists Meeting, Brussels, 18-21 Nov 1975 (Contract NASw-2791)

(NASA-TT-F-17125) Avail NTIS HC \$4 00 CSCL 01C

The results of studies of a general character that were carried out on several models in a spin wind tunnel are presented The first topic taken up concerns the effect of rockets used as a rescue device from a spin, the study has been limited to light planes, however, certain conclusions could be valid, at least qualitatively, for other types of airplanes, military ones in particular The second topic concerns the effect of an dissymmetric load on the spin of airplanes of all types military, light or transport The dissymmetry considered is a purely mass-related one such as could be due to fuel airfoil Meanwhile for military planes the dissymmetry caused this time by external loads (whose dissymmetry is both weight and geometry related) is also taken into consideration Author

**N76-28231# Air Force Packaging Evaluation Agency Wright-Patterson AFB Ohio**

**ENVIRONMENTAL STUDY OF EXTERNAL AIRCRAFT FUEL TANKS STORED IN RIGID POLYURETHANE FOAM**

John A Hincks Dec 1975 22 p (AD-A021200 DSPS-75-74) Avail NTIS CSCL 13/4

External aircraft fuel tanks were foamed-in-place by Sacramento ALC for the purpose of testing totally encapsulated items Four tanks were received by the Air Force Packaging Evaluation Agency (AFPEA) and subjected to the aggressive saline atmosphere and severe weathering environment at an Eglin AFB test station located on the Gulf of Mexico Although the tanks had been transported and stored outside in open wooden crates and more recently in improved galvanized slotted angle steel framework, for extended periods of time, approximately 20% of the assembled tanks were corroding, leaving much room for improvement This study indicated that the method of encapsulating the items in polyurethane foam is not only more cost effective but shows marked improvement in corrosion resistance and affords physical protection as well GRA

**N76-28232\*# Washington Univ, Seattle WIND SHEAR DETECTION USING MEASUREMENT OF AIRCRAFT TOTAL ENERGY CHANGE**

Robert G Joppa May 1976 13 p ref (Grant NCA2-OP850-601)

(NASA-CR 137839) Avail NTIS HC \$3 50 CSCL 01D

Encounters with wind shears are of concern and have caused major accidents, particularly during landing approaches Changes in the longitudinal component of the wind affect the aircraft by changing its kinetic energy with respect to the air It is shown that an instrument which will measure and display the rate of change of total energy of the aircraft with respect to the air will give a leading indication of wind shear problems The concept is outlined and some instrumentation and display considerations are discussed Author

**N76-28236\*# Kanner (Leo) Associates Redwood City, Calif CERTAIN CONCLUSIONS ON THE SUPERSONIC TRANSPORT AIRCRAFT BOOM**

J C Wanner Washington NASA Aug 1976 16 p Transl into ENGLISH of Quelques Conclusions sur le Bang des Avions de Transport Supersoniques (report) Chatillon France ONERA Direction Technique 29 Apr 1976 12 p (Contract NASw-2790)

(NASA-TT-F-17149) Avail NTIS HC \$3 50 CSCL 20A

Certain conclusions are reached regarding the flight of supersonic transport aircraft The bearable limit of the boom is situated below 0.8 millibar The mechanical effects on structures and physiological effects on humans and animals are negligible but for sociophysiological reasons supersonic flight over inhabited areas should be banned and steps must be taken to determine that the focalization point is situated in uninhabited areas

Author

**N76-28237\*# Detroit Diesel Allison Indianapolis Ind Dept of Combustion Research and Development POLLUTION REDUCTION TECHNOLOGY PROGRAM, TURBOPROP ENGINES, PHASE 1**

R D Anderson, A S Herman J G Tomlinson J M Vaught and A J Verdouw Mar 1976 134 p refs

(Contract NAS3-18561)

(NASA-CR-135040, EDR-8708) Avail NTIS HC \$6 00 CSCL 21E

Exhaust pollutant emissions were measured from a 501-D22A turboprop engine combustor and three low emission combustor types -- reverse flow prechamber and staged fuel operating over a fuel-air ratio range of 0.096 to 0.20 The EPAP LTO cycle data were obtained for a total of nineteen configurations Hydrocarbon emissions were reduced from 15.0 to 3 lb/1000 Hp-Hr/cycle CO from 31.5 to 4.6 lb/1000 Hp-Hr/cycle with an increase in NOx of 17 percent which is still 25% below the program goal The smoke number was reduced from 59 to 17 Emissions given here are for the reverse flow Mod IV combustor which is the best candidate for further development into eventual use with the 501-D22A turboprop engine Even lower emissions were obtained with the advanced technology combustors Author

**N76-28238\*# Rensselaer Polytechnic Inst Troy NY Electrical and Systems Engineering Dept**

**REDUCED STATE FEEDBACK GAIN COMPUTATION Final Report, 1 Jun 1975 - 30 Nov 1976**

Howard Kaufman 30 Nov 1976 41 p refs

(Grant NSG-1188)

(NASA-CR-148491) Avail NTIS HC \$4 00 CSCL 01C

Because application of conventional optimal linear regulator theory to flight controller design requires the capability of measuring and/or estimating the entire state vector it is of interest to consider procedures for computing controls which are restricted to be linear feedback functions of a lower dimensional output vector and which take into account the presence of measurement noise and process uncertainty Therefore a stochastic linear model that was developed is presented which accounts for aircraft parameter and initial uncertainty measurement noise turbulence pilot command and a restricted number of measurable outputs Optimization with respect to the corresponding output feedback gains was performed for both finite and infinite time performance indices without gradient computation by using Zangwill's modification of a procedure originally proposed by Powell Results using a seventh order process show the proposed procedures to be very effective

Author

**N76-28239\*# Virginia Military Inst Lexington A VELOCITY-COMMAND CONTROLLER FOR A VTOL AIRCRAFT**

Gerald F Reid 1976 5 p refs

(Grant NGR-47-018-005)

(NASA-CR-148535 APPL-5-2) Avail NTIS HC \$3 50 CSCL 01C

A technique is presented for calculating feedback and feedforward gain matrices that enable a VTOL aircraft to track input commands of forward and vertical velocity while maintaining acceptable responses to pilot inputs Leverrier's algorithm is used for determining a set of state-variable feedback gains that force the closed-loop poles and zeros of one pilot-input transfer function to pre-selected positions in the s-plane This set of feedback gains is then used to calculate the feedback and feedforward gains for the velocity-command controller The method is computationally attractive since the gains are determined by solving systems of linear simultaneous equations The method is used in a digital simulation of the CH-47 helicopter to control longitudinal dynamics Author

**N76-28272\*#** Jet Propulsion Lab Calif Inst of Tech Pasadena  
**TENTH AEROSPACE MECHANISMS SYMPOSIUM**  
 1 Jul 1976 234 p refs Symp held at Pasadena Calif  
 22-23 Apr 1976, sponsored in part by LMSC  
 (Contract NAS7-100)  
 (NASA-CR-148515 JPL-TM-33-777) Avail NTIS HC \$8 00  
 CSCL 22D

Design studies and analyses were performed to describe the loads and dynamics of the space shuttle tail service masts. Of particular interest is the motion and interaction of the umbilical carrier plate lanyard system vacuum jacketed hoses latches links and masthead.

**N76-28514\*#** National Aeronautics and Space Administration  
 Ames Research Center Moffett Field Calif  
**AN EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF THE FLOW FIELD ABOUT A TRANSONIC AIRFOIL IN SUPERCRITICAL FLOW WITH TURBULENT BOUNDARY-LAYER SEPARATION**

Morris W Rubesin Arthur F Okuno Lionel L Levy Jr John B McDevitt and H Lee Seegmiller Jul 1976 12 p refs  
 (NASA-TM-X-73157 A-6690) Avail NTIS HC \$3 50 CSCL 20D

A combined experimental and computational research program is described for testing and guiding turbulence modeling within regions of separation induced by shock waves incident in turbulent boundary layers. Specifically studies are made of the separated flow the rear portion of an 18%-thick circular-arc airfoil at zero angle of attack in high Reynolds number supercritical flow. The measurements include distributions of surface static pressure and local skin friction. The instruments employed include high-frequency response pressure cells and a large array of surface hot-wire skin-friction gages. Computations at the experimental flow conditions are made using time-dependent solutions of ensemble-averaged Navier-Stokes equations plus additional equations for the turbulence modeling. Author

**N76-28553\*#** SKF Industries Inc King of Prussia Pa  
**MICROFOG LUBRICATION FOR AIRCRAFT ENGINE BEARINGS** Technical Report, Sep 1972 - Jun 1975  
 J W Rosenlieb Apr 1976 135 p refs  
 (Contract NAS3-16826)  
 (NASA-CR-134977 SKF-AL75T032) Avail NTIS HC \$6 00  
 CSCL 13I

An analysis and system study was performed to provide design information regarding lubricant and coolant flow rates and flow paths for effective utilization of the lubricant and coolant in a once through bearing oil mist (microfog) and coolant air system. Both static and dynamic tests were performed. Static tests were executed to evaluate and calibrate the mist supply system. A total of thirteen dynamic step speed bearing tests were performed using four different lubricants and several different mist and air supply configurations. The most effective configuration consisted of supplying the mist and the major portion of the cooling air axially through the bearing. The results of these tests have shown the feasibility of using a once through oil mist and cooling air system to lubricate and cool a high speed high temperature aircraft engine mainshaft bearing. Author

**N76-28949\*#** Princeton Univ NJ  
**COMBUSTION CONTRIBUTION TO NOISE IN JET ENGINES**  
 E G Plett A N Abdelhamid D T Harje, and M Summerfield  
 Washington NASA Jul 1976 42 p refs  
 (Grant NGR-31-001-241)  
 (NASA-CR-2704 Rept-1146) Avail NTIS HC \$4 00 CSCL 20A

The relative importance of combustion as a source of noise in a flow regime representative of a subsonic jet engine exhaust was investigated. The combustion noise source characteristics were obtained from pressure and temperature fluctuation measurements in the combustor and exhaust nozzle. The similarity between the fluctuations in this source region and the far field

noise were compared. In the jet exhaust velocity range between 450 and 660 ft/sec investigated in detail the frequencies of dominant pressure and temperature fluctuations in the combustor were also the frequencies of the dominant far field noise. The overall noise levels were 14 to 20 dB higher than from a corresponding clean jet in the same velocity range. Thus it seemed clear that the unsteadiness associated with the combustion process was responsible for the dominant noise in the far field. A simple analysis to predict the far field noise due to the internal pressure fluctuations causing exit plane velocity fluctuations produced trends closely resembling the measured results but under predicted the far field noise over the spectral range examined. The possible reason for the higher far field noise is direct transmission of acoustic waves through the nozzle which was not accounted for in the prediction scheme. Author

**N76-28957\*#** National Aeronautics and Space Administration  
 Langley Research Center Langley Station Va  
**AIRFRAME SELF-NOISE FOUR YEARS OF RESEARCH**  
 Jay C Hardin Jul 1976 73 p refs  
 (NASA-TM-X-73908) Avail NTIS HC \$4 50 CSCL 20A

A critical assessment of the state of the art in airframe self-noise is presented. Full-scale data on the intensity spectra and directivity of this noise source are evaluated in the light of the comprehensive theory developed by Ffowcs-Williams and Hawkins. Vibration of panels on commercial aircraft is identified as a possible additional source of airframe noise. The present understanding and methods for prediction of other component sources - airfoils struts and cavities - are discussed and areas for further research as well as potential methods for airframe noise reduction are identified. Finally the various experimental methods which have been developed for airframe noise research are discussed and sample results are presented. Author

**N76-28958\*#** Systems Research Labs Inc Newport News Va  
 NASA Div  
**PARAMETRIC STUDY OF THE NOISE PRODUCED BY THE INTERACTION OF THE MAIN ROTOR WAKE WITH THE TAIL ROTOR**  
 John C Balcerak [1976] 70 p refs  
 (Contract NAS1-13690)  
 (NASA-CR-145001) Avail NTIS HC \$4 50 CSCL 20A

A model was designed fabricated and wind tunnel tested to identify some of the parameters which were pertinent to the noise produced by the interaction of the main rotor wake with the tail rotor. The model provided for variations in many geometric and operating parameters. The initial set of tests indicated that the noise produced by the tail rotor was in general sensitive to the location of the vortex interaction on the tail rotor disk direction of rotation lateral rotor fin spacing tip speed and the operating mode of the tail rotor and generally insensitive to main rotor thrust coefficient longitudinal spacing and tail rotor to main rotor rotational speed ratios. Refinements in the analyses to adequately predict the noise phenomenon have been outlined to complement further experimental investigations. Author

**N76-28959\*#** Tennessee Univ Knoxville  
**NOISE SUPPRESSION WITH HIGH MACH NUMBER INLETS**  
 Edward Lumsdaine Jenn G Cherng and Ismail Tag Washington  
 NASA Jul 1976 108 p refs  
 (NASA-CR-2708) Avail NTIS HC \$5 50 CSCL 20A

Experimental results were obtained for two types of high Mach number inlets one with a translating centerbody and a fixed geometry inlet (collapsing cowl) with no centerbody. The aerodynamic and acoustic performance of these inlets was examined. The effects of area ratio length/diameter ratio and lip geometry were among several parameters investigated. The translating centerbody type inlet was found to be superior to the collapsing cowl both acoustically and aerodynamically particularly for area ratios greater than 1.5. Comparison of length/diameter ratio and area ratio effects on performance near choked flow showed the latter to be more significant. Also greater high frequency noise attenuation was achieved by increasing Mach number from low to high subsonic values. Author

**N76-28960\*# Boeing Commercial Airplane Co Seattle Wash  
EFFECTS OF MOTION ON JET EXHAUST NOISE FROM  
AIRCRAFT Final Report**

K S Chun C H Berman and S J Cowan Washington NASA  
Jun 1976 221 p refs  
(Contract NAS3-18539)  
(NASA-CR-2701 D6-41995) Avail NTIS HC \$7 75 CSCL  
20A

The various problems involved in the evaluation of the jet noise field prevailing between an observer on the ground and an aircraft in flight in a typical takeoff or landing approach pattern were studied Areas examined include (1) literature survey and preliminary investigation (2) propagation effects (3) source alteration effects and (4) investigation of verification techniques Sixteen problem areas were identified and studied Six follow-up programs were recommended for further work The results and the proposed follow-on programs provide a practical general technique for predicting flyover jet noise for conventional jet nozzles Author

**N76-28961\*# Bolt Beranek and Newman Inc Cambridge  
Mass**

**LANDING GEAR AND CAVITY NOISE PREDICTION**

Donald B Bliss and Richard E Hayden Washington NASA  
Jul 1976 57 p refs  
(NASA Order L-18051-A)  
(NASA-CR-2714) Avail NTIS HC \$4 50 CSCL 20A

Prediction of airframe noise radiation from the landing gear and wheel wells of commercial aircraft is examined Measurements of these components on typical aircraft are presented and potential noise sources identified Semiempirical expressions for the sound generation by these sources are developed from available experimental data and theoretical analyses These expressions are employed to estimate the noise radiation from the landing gear and wheel wells for a typical aircraft and to rank order the component sources Author

**N76-28962\*# New York Univ NY Div of Applied Science  
SONIC BOOM RESEARCH Progress Report, 1 May - 31 Jul  
1976**

Victor Zakkay and Lu Ting 31 Jul 1976 15 p refs  
(Grant NGL-33-016-119)  
(NASA-CR-148548) Avail NTIS HC \$3 50 CSCL 20A

A computer program for CDC 6600 is developed for the nonlinear sonic boom analysis including the asymmetric effect of lift near the vertical plane of symmetry The program is written in FORTRAN 4 language This program carries out the numerical integration of the nonlinear governing equations from the input data at a finite distance from the airplane configuration at a flight altitude to yield the pressure signitude at ground The required input data and the format for the output are described A complete program listing and a sample calculation are given Author

**N76-29054# Committee on Aeronautical and Space Sciences  
(U S Senate)**

**NASA AUTHORIZATION FOR FISCAL YEAR 1977,  
PART 3**

Washington GPO 1976 656 p refs Hearings on S 2864 before Comm on Aeron and Space Sci, 94th Congr, 2d Sess 17 24 Feb and 3 Mar 1976  
(GPO-68-258) Avail Comm on Aeron and Space Sci

Appropriations to the National Aeronautics and Space Administration are discussed Development of aircraft engines which reduce fuel consumption jet aircraft noise, and exhaust gases is described along with the tracking and data acquisition support for the Space Shuttle the Viking lander, and Helios missions J M S

**N76-29056# Committee on Appropriations (U S House)  
DEPARTMENT OF TRANSPORTATION AND RELATED  
AGENCIES APPROPRIATIONS FOR 1977, PART 1**

Washington GPO 1976 758 p Hearings before a subcomm of the Comm on Appropriations 94th Congr 2d Sess 4 Feb 1976

(GPO-68-927) Avail Comm on Appropriations

The hearings concerning the budget for the Department of Transportation are reported Legislative programs and program obligations are discussed along with the U S Coast Guard FAA Federal Highway Administration Amtrak and the Urban Mass Transportation Administration The hearings concerning the budget for the National Transportation Safety Board are included F O S

**N76-29057# Committee on Aeronautical and Space Sciences  
(U S Senate)**

**NASA AUTHORIZATION FOR FISCAL YEAR 1977  
PART 4 INDEX**

Washington GPO 1976 138 p Hearings on S 2864 before Comm on Aeron and Space Sci 94th Congr 2d Sess 1976 (GPO-73-502) Avail Comm on Aeron and Space Sci

An index is presented of the hearings dealing with the NASA authorization for FY-1977 J M S

**N76-29060\*# Denver Research Inst Colo Industrial Economics  
Div**

**BENEFITS BRIEFING NOTEBOOK THE SECONDARY  
APPLICATION OF AEROSPACE TECHNOLOGY IN OTHER  
SECTORS OF THE ECONOMY**

[1976] 174 p  
(Contract NASw-2607)  
(NASA-CR-148509 Rept-76/1) Avail NTIS HC \$6 75 CSCL  
05A

Resource information on the transfer of aerospace technology to other sectors of the U S economy is presented The contents of this notebook are divided into three sections (1) benefit cases, (2) transfer overview and (3) indexes Transfer examples relevant to each subject area are presented Pertinent transfer data are given The Transfer Overview section provides a general perspective for technology transfer from NASA to other organizations In addition to a description of the basic transfer modes the selection criteria for notebook examples and the kinds of benefit data they contain are also presented Author

**N76-29064\*# Princeton Univ NJ Center for Environmental  
Studies and Transportation Program**

**SUBURB-TO-SUBURB INTERCITY TRAVEL ENERGY, TIME  
AND DOLLAR EXPENDITURES**

Margaret Fulton Fels Jun 1976 70 p refs  
(Grant NSG-2037)  
(NASA-CR-137911 Rept-76-TR-10) Avail NTIS HC \$4 50  
CSCL 13F

The effect of adding suburb to terminal and terminal to suburb travel is examined The energy consumed in entire trips was estimated The total energy costs are compared with total travel times and dollar costs to the traveler Trips between origins in seven suburbs of Newark New Jersey and destinations in two Washington D C suburbs are analyzed Author

**N76-29152\*# Sikorsky Aircraft Stratford Conn  
DERIVATION OF EQUATIONS OF MOTION FOR MULTI-  
BLADE ROTORS EMPLOYING COUPLED MODES AND  
INCLUDING HIGH TWIST CAPABILITY**

R Sopher 27 Feb 1975 295 p refs  
(Contract NAS2-6463)  
(NASA-CR-137898 SER-50912) Avail NTIS HC \$9 25 CSCL  
01A

The derivation is described of the equations of motion for a multiblade rotor The analysis advances on current capabilities for calculating rotor responses by introducing a high twist capability and coupled flatwise-edgewise assumed normal modes instead of uncoupled flatwise and edgewise assumed normal modes The torsion mode is uncoupled as before Features inherited from previous work include the support system models consisting of complete helicopters in free flight or grounded flexible supports arbitrary rotor-induced inflow and arbitrary vertical gust model Author

**N76-29153\*# Sikorsky Aircraft Stratford Conn  
USER'S MANUAL FOR THE COUPLED MODE VERSION**

# OF THE NORMAL MODES ROTOR AEROELASTIC ANALYSIS COMPUTER PROGRAM

Russell R Bergquist Raymond G Carlson A J Landgrebe and T A Egolf [1974] 145 p refs  
(Contract NAS2-6463)  
(NASA-CR-137899 SER-50910) Avail NTIS HC \$6 00 CSCL 01A

This Users Manual was prepared to provide the engineer with the information required to run the coupled mode version of the Normal Modes Rotor Aeroelastic Analysis Computer Program. The manual provides a full set of instructions for running the program including calculation of blade modes, calculations of variable induced velocity distribution and the calculation of the time history of the response for either a single blade or a complete rotor with an airframe (the latter with constant inflow). Author

## N76-29156\*# National Aeronautics and Space Administration Langley Research Center, Langley Station Va EFFECT OF WING-TIP DIHEDRAL ON THE LONGITUDINAL AND LATERAL AERODYNAMIC CHARACTERISTICS OF A SUPERSONIC CRUISE CONFIGURATION AT SUBSONIC SPEEDS

Karen E Washburn (Purdue Univ) and Blair B Gloss Aug 1976 42 p refs  
(NASA-TM-X-72693) Avail NTIS HC \$4 00 CSCL 01A

Force and moment data studies were conducted to determine the effect of wing-tip dihedral on the longitudinal and lateral aerodynamic characteristics of a supersonic cruise fighter configuration. Oil flow studies were also performed to investigate the model surface flow. Three models were tested: a flat (0 deg dihedral) wing tip, a dihedral, and an anhedral wing tip. The tests were conducted at the NASA Langley high-speed 7- by 10-foot wind tunnel. Author

## N76-29157\*# Wichita State Univ Kans REFLECTION-PLANE TESTS OF SPOILERS ON AN ADVANCED TECHNOLOGY WING WITH A LARGE FOWLER FLAP

W H Wentz Jr and C G Volk Jr Washington NASA Jul 1976 90 p refs  
(Grant NSG-1118)  
(NASA-CR-2696 WSU-AR-75-2) Avail NTIS HC \$5 00 CSCL 01A

Wind tunnel experiments were conducted to determine the effectiveness of spoilers applied to a finite-span wing which utilizes the GA(W)-1 airfoil section and a 30% chord full-span Fowler flap. A series of spoiler cross sectioned shapes were tested utilizing a reflection-plane model. Five-component force characteristics and hinge moment measurements were obtained. Results confirm earlier two-dimensional tests which showed that spoilers could provide large lift increments at any flap setting and that spoiler control reversal tendencies could be eliminated by providing a vent path from lower surface to upper surface. Performance penalties due to spoiler leakage airflow were measured. Author

## N76-29167\*# National Aeronautics and Space Administration Langley Research Center, Langley Station Va THE EFFECT OF WINGLETS ON THE STATIC AERODYNAMIC STABILITY CHARACTERISTICS OF A REPRESENTATIVE SECOND GENERATION JET TRANSPORT MODEL

Peter F Jacobs and Stuart G Flechner Washington NASA Jul 1976 32 p refs  
(NASA-TN-D-8267, L-10297) Avail NTIS HC \$4 00 CSCL 01A

A baseline wing and a version of the same wing fitted with winglets were tested. The longitudinal aerodynamic characteristics were determined through an angle-of-attack range from -1 deg to 10 deg at an angle of sideslip of 0 deg for Mach numbers of 0.750, 0.800, and 0.825. The lateral aerodynamic characteristics were determined through the same angle-of-attack range at fixed sideslip angles of 2.5 deg and 5 deg. Both configurations were investigated at Reynolds numbers of 13,000,000, per meter (4,000,000 per foot) and approximately 20,000,000 per meter (6,000,000 per foot). The winglet configuration showed slight increases over the baseline wing in static longitudinal and lateral

aerodynamic stability throughout the test Mach number range for a model design lift coefficient of 0.53. Reynolds number variation had very little effect on stability. Author

## N76-29168# Northrop Corp Hawthorne, Calif Aircraft Div UNSTEADY TWO-DIMENSIONAL SUBSONIC, TRANSONIC, AND SUPERSONIC FLOW CALCULATIONS BY THE METHOD OF CHARACTERISTICS Final Report, Mar 1973 - Feb 1976

C W Chu and S Nadir Feb 1976 81 p refs  
(Contract N00014-73-C-0237 NR Proj 061-213)  
(AD-A021481, NOR-76-19) Avail NTIS CSCL 20/4

A method of characteristics for calculating inviscid unsteady two-dimensional flow is presented. The compatibility relations for two-dimensional unsteady compressible flow are first derived and the boundary conditions are discussed. Then the generalized finite-difference approximations of the compatibility relation are presented. This is followed by a description of the numerical scheme and some special procedures. Since the equations governing unsteady inviscid compressible flow are always hyperbolic, the method is applicable to subsonic, transonic and supersonic flows, and the present scheme has been used to calculate flow fields over airfoils in all three speed regimes. Following the description of the numerical scheme and procedures, flow field examples in each of the three speed regimes are presented and discussed. Finally conclusions are drawn and some future extensions are indicated. GRA

## N76-29172# West Virginia Univ Morgantown Dept of Aerospace Engineering ASYMMETRIC ENTRAINMENT OF 2-D CURVED JETS

Subrato Chandra and John L Loth Aug 1975 196 p refs  
(Contract N00014-73-A-0417-0003, NR Proj 215-227)  
(AD-A021967 TR-45) Avail NTIS CSCL 01/3

The control of VTOL aircraft during transition from hover to forward flight is complicated by the lifting jet-airframe interaction. This analysis is concerned with the entrainment aspect of two dimensional thick curved jets. A realistic mathematical model of such jets should account for different entrainment rates and the total pressure decay in the jet. The present theoretical analysis predicts curved jet characteristics needed for an accurate mathematical modelling of two dimensional lifting jets. The present analysis performs an integral method analysis of the curved jet using incompressible, fully turbulent, curved, free jet equations. Integral methods need specified jet edge velocity distributions. This streamwise velocity distribution depends on the airfoil geometry as well as on the jet. The present theory approximately retains this ellipticity by obtaining the streamwise jet edge velocities from a nonlinear iterative potential flow analysis of a thin jet issuing from the trailing edge of a hinged flat plate. The results of the present analysis are in agreement with available straight and curved jet results. The present theory predicts significantly (10%-20%) different entrainment rates near the exit where the curvature is maximum. Since  $V/STOL$  lift moment, and pressure drag are significantly affected by the jet entrainment, one should incorporate the asymmetry of entrainment rates of curved thick jets in prediction methods. Author (GRA)

## N76-29174# Naval Civil Engineering Lab Port Hueneme, Calif REDUCTION OF V/STOL DOWNWASH EFFECTS BY JET EXHAUST FLOW CONTROL Final Report, Jul 1973 - Jun 1974

D E Williams Dec 1975 55 p refs  
(SF53536001)  
(AD-A021965 CEL-TN-1410) Avail NTIS CSCL 01/3

The performance of V/STOL aircraft is influenced significantly by ground effects during landing and takeoff when the propulsive flow of the aircraft is directly downward. To mitigate downwash effects, a new landing mat concept was developed at Civil Engineering Laboratory whereby exhaust flow is controlled by either a very thin array of diamond patterns or parallel ribs. The impinging jet flow aligns itself with the long axis of the grid pattern, expanding in two directions along a single line rather than radially outward over the plane of the ground. Grid height or thickness is small compared with jet diameter. A method for

calculating grid height was developed by combining Froessling's solution for boundary layer thickness and Glauert's solution for wall jet thickness  
Author (GRA)

**N76-29175#** Air Force Inst of Tech Wright-Patterson AFB, Ohio School of Engineering  
**AN AERODYNAMIC INVESTIGATION OF A LOW ASPECT RATIO WING M S Thesis**

Leonard V McCommon Dec 1975 126 p refs  
(AF Proj 1990)

(AD-A021733, GAE/AE/75D-15) Avail NTIS CSCL 01/1

The study consisted of modeling and testing a high-speed, low aspect ratio flying wing (no conventional center body or fuselage) to determine its lift drag and static stability characteristics at Mach numbers of 0.70 to 0.86 Six different configurations of stabilizing fins were tested along with the basic finless configuration Wind tunnel test results are presented in graphic and tabular form for use in further design studies  
GRA

**N76-29176#** Northrop Corp, Hawthorne, Calif Aircraft Div  
**WAVE DRAG REDUCTION FOR AIRCRAFT FUSELAGES Interim Report**

C W Chu, J Der Jr and H Ziegler Warminster, Pa Naval Air Develop Center Aug 1975 78 p refs  
(Contract N62269-74-C-0470)

(AD-A021718, NOR-75-70) Avail NTIS CSCL 01/1

A numerical procedure has been developed to minimize the wave drag of a forward aircraft fuselage and canopy configuration subject to realistic constraints imposed by design requirements The procedure makes use of the Latin Square sampling technique and the Three-Dimensional Method of Characteristics The former is used to efficiently sample the family of configurations, and the latter is used to accurately calculate the wave drags of the sampled configurations The calculated wave drag coefficients are then used to derive a functional dependence of the wave drag on the geometric variables that define the family of configurations The minimum wave drag configuration can be obtained by minimizing the wave drag function subject to a given set of constraints A new concept which enables the minimizing procedure to improve by 'learning' from experience is presented This concept proves very useful and can be applied to other optimization procedures using Latin Square sampling Finally, the wave drag reduction procedure is demonstrated using the F-4 fuselage as the baseline The results are presented and discussed  
Author (GRA)

**N76-29177#** University of Southern Calif, Los Angeles Dept of Aerospace Engineering  
**ON LIFTING-LINE THEORY IN UNSTEADY AERODYNAMICS**

H K Cheng Jan 1976 28 p refs  
(Contract N00014-75-C-0520, NR Proj 061-192)

(AD-A021449, USCAE-133) Avail NTIS CSCL 01/1

This paper presents a linear theory of a high-aspect-ratio planar wing with a curved center line undergoing unsteady motion in an incompressible flow with a uniform freestream Five distinct frequency ranges are identified Except in the low-frequency range where the wave length is comparable to the wing span, matched inner and exterior solutions are obtained The significance of the induced upwash due to sweep, and the usefulness of the center-line curvature in mitigating this upwash effect, are explained The theory provides a basic framework wherein the lunate-tail problem in aquatic animal propulsion can be studied  
GRA

**N76-29178#** West Virginia Univ, Morgantown Dept of Aerospace Engineering

**LIFTING JET FLOW FIELDS Final Contract Report**

J L Loth, Richard E Walters and Subrato Chandra Aug 1975 51 p refs

(Contract N00014-73-A-0417-0003, NR Proj 215-227)

(AD-A021968, TR-46) Avail NTIS CSCL 01/3

The control of VTOL aircraft during transition from hover to forward flight is complicated due to the complex airframe-jet interaction This investigation is concerned with mathematical modelling of asymmetric entrainment of lifting jets The analysis is for two dimensional augmenters used on VTOL aircraft The

theoretical analysis of the lifting jets was limited to two dimensional curved jets in forward flight and out of ground effects The aim was to predict the asymmetric entrainment rates of the curved jet along with its decay rate of the maximum velocity, and jet width growth rate The results were obtained using turbulent curved free jet theory in conjunction with thin jet potential flow models to obtain the jet edge streamwise velocities To test the effects of asymmetric entrainment the results were inserted in a thick jet potential flow computer program to obtain transition flight performance of a typical VTOL augmenting wing A concurrent experimental study was undertaken to determine curved jet characteristics issuing from a two dimensional model Maximum velocity decay, jet curvature jet width velocity and pressure profiles were measured Good agreement has been obtained between the theoretical predicted and experimental measured curved jet characteristics It was necessary to adjust the constant in the turbulent shear stress model to get this good agreement Both experiments on the straight and curved jets at West Virginia University and by others have been compared with the theory  
GRA

**N76-29180#** Air Force Inst of Tech, Wright-Patterson AFB, Ohio School of Engineering

**AN EXPERIMENTAL INVESTIGATION OF THE DRAG ON A CIRCULAR CYLINDER AND CURVED SHELL IN TRANSONIC FLOW M S Thesis**

Steve Borah Dec 1975 86 p refs

(AD-A021874, GAE/AE/75D-8) Avail NTIS CSCL 20/4

This study was one in a series by the Air Force Flight Dynamics Laboratory in large turret aerodynamic research The objective of the study was the reduction of transonic drag of a particular turret configuration by the addition of area rule fairings Wind tunnel models were tested at transonic Mach numbers from 0.6 to 0.9 An internally mounted force balance and unsteady pressure transducers were used to measure the forces and pressure variations on the model Fairings were placed beside and aft of the turret in an effort to reduce the transonic turret drag The least drag configuration was a single fairing mounted behind the turret This design had as much as a 55% drag reduction from the bare turret This model also created the smallest pressure fluctuations in a circular cavity in the side of the turret  
GRA

**N76-29181#** Air Force Academy, Colo Frank J Seiler Research Lab

**ON THE POTENTIAL FLOW ABOUT AN AIRFOIL IN GROUND EFFECT AND UNDERGOING UNSTEADY MOTION Final Report**

Robert A Golobic Dec 1975 43 p refs

(AF Proj 7905)

(AD-A021749, SRL-TR-75-0021) Avail NTIS CSCL 20/4

A computer solution employing Pistolesi's theorem and the method of images has been developed to determine the potential flow about an airfoil in ground effect undergoing unsteady motion The airfoil mean camber line is broken into a finite number of straight line segments Vortices are used to model the airfoil potential and the wake potential Although the solution is restricted to thin airfoils it is not restricted to small angles of attack or small camber Solutions of an airfoil undergoing harmonic motion and a C-130 short take-off maneuver are presented  
GRA

**N76-29182#** Aerospace Research Labs Wright-Patterson AFB Ohio

**MIXING DUCT PRESSURE DISTRIBUTIONS AND EXHAUST FLOW CHARACTERISTICS OF A HIGH TEMPERATURE AND PRESSURE CYLINDRICAL EJECTOR Interim Technical Report, Jun 1973 - May 1974**

Brian Quinn and Howard L Toms, Jr Jun 1975 95 p refs  
(AF Proj 7116)

(AD-A021626, ARL-75-0227) Avail NTIS CSCL 01/3

The thermodynamic and mixing characteristics of a family of inlet area ratio 26 ejectors have been measured across a range of primary reservoir pressures (0 to 80 psig) and temperatures (65 to 1,000 F) The length-to-duct diameter ratio of the ejectors was the family parameter and varied from 12.36 to 3.46 The distribution of pressure along the wall of the



mixing duct clearly identified up to three distinct modes of turbulent mixing. They also substantiated prior observations that mixing is accelerated by heating the primary jet. The discrete modes of mixing were subjectively related to the acoustic properties of the greatly underexpanded primary nozzle. GRA

**N76-29184#** ARO Inc. Arnold Air Force Station, Tenn.  
**INFLUENCES OF STING SUPPORT ON AERODYNAMIC LOADS ACTING ON CAPTIVE STORE MODELS** Final Report, Apr 1973 - Jun 1975

R E Dix AEDC Mar 1976 329 p refs  
 (AF Proj 2567)

(AD-A02257 ARO-PWT-TR-75-95 AEDC-TR-76-1  
 AFATL-TR-76-25) Avail NTIS CSCL 01/1

In a series of wind tunnel tests measurements were made of the aerodynamic loads acting on eight different store configurations mounted in the external captive position on a one-twentieth-scale model of the F-4C aircraft. Store models included blunt and contoured afterbody shapes, stable and unstable designs and large (one per pylon) and small (rack-mounted) configurations. The tests were conducted in an effort to evaluate sting effects on captive store loads. Sting effects were considered to consist of two contributions: the effect of altering the afterbody of a store to allow insertion of a sting, and the effect of the presence of the sting. Altering the afterbody of an unstable store influenced captive loads less than altering a stable configuration. It was also determined that the presence of a sting affected most the pitching and yawing moments. GRA

**N76-29187#** Advisory Group for Aerospace Research and Development, Paris (France)

**ADVANCED TECHNIQUES IN CRASH IMPACT PROTECTION AND EMERGENCY EGRESS FROM AIR TRANSPORT AIRCRAFT**

R G Snyder (Michigan Univ., Ann Arbor) Jun 1976 320 p refs

(AGARD-AG-221, AGARDograph-221 ISBN-92-835-1218-9)  
 Avail NTIS

Analysis of all NATO member air transport accidents 1964-1975 revealed that injuries and fatalities, when such information could be determined, were primarily due to the post-crash effects of fire, smoke and toxic fumes, and secondarily to crash impact. Future air transport design trends were reviewed and approximately 150 advanced crash-impact and emergency-egress concepts, devices, and state-of-the-art techniques were evaluated. These included occupant restraints, smoke hoods, aisle and egress emergency lighting, passenger warning systems, escape slides and devices, heat shields, high-energy emergency egress systems and emergency inflight egress systems. It was concluded that rear-facing passenger seats, the NASA Ames (21+6 sub x sub 45+6 sub z) airline seat, and the production sheldahl smoke hood can provide significantly improved occupant protection while high-energy emergency egress systems appear promising for future aircraft. More research is needed to improve passenger warning and public address systems. Concepts of emergency inflight egress are not yet feasible although technically within the state-of-the-art. Author

**N76-29188\*#** Douglas Aircraft Co., Inc. Long Beach, Calif.  
**STUDY OF SHORT-HAUL AIRCRAFT OPERATING ECONOMICS PHASE 2. AN ANALYSIS OF THE IMPACT OF JET MODERNIZATION ON LOCAL SERVICE AIRLINE OPERATING COSTS** Final Report

Donald A Andrastek May 1976 155 p refs  
 (Contract NAS2-8549)

(NASA-CR-137863 MDC-J7245) Avail NTIS HC \$6.75 CSCL 05C

The objectives of this phase of the study were (1) to assess the 10 year operating cost trends of the local service airlines operating in the 1965 through 1974 period, (2) to glean from these trends the technological and operational parameters which were impacted most significantly by the transition to newer pure jet, short haul transports, and effected by changing fuel prices and cost of living indices, and (3) to develop, construct,

and evaluate an operating cost forecasting model which would incorporate those factors which best predicted airline total operating cost behavior over that 10-year period. Author

**N76-29190#** Department of Transportation, Washington, D.C.  
**THE SECRETARY'S DECISION ON CONCORDE SUPERSONIC TRANSPORT**

4 Feb 1976 99 p refs

(AD-A022340) Avail NTIS CSCL 01/2

It has been decided to permit British Airways and Air France to conduct limited scheduled commercial flights into the United States for a trial period not to exceed 16 months under certain limitations and restrictions. It has been decided also to proceed with a proposed high altitude pollution program (HAPP) to produce the data base necessary for the development of national and international regulation of aircraft operations in the stratosphere. GRA

**N76-29191#** National Transportation Safety Board, Washington, D.C. Bureau of Aviation Safety

**US GENERAL AVIATION TAKEOFF ACCIDENTS: THE ROLE OF PREFLIGHT PREPARATION**

10 Mar 1976 30 p

(PB-252203/5 NTSB-AAS-76-2) Avail NTIS HC \$4.00 CSCL 01B

The report analyzes general aviation takeoff accidents which occurred in 1974 with special emphasis on the involvement of preflight planning. The most frequently referenced cause/factors in takeoff accidents are discussed in relation to the type certificate held by the pilot. Factors to consider during preflight preparation are included. From these discussions, remedial measures to reduce the number of takeoff accidents were formulated. GRA

**N76-29211#** Naval Air Development Center, Warminster, Pa.  
 Dept. of Aero-Electronic Technology

**DIRECTION OF ARRIVAL ANGLE PREDICTION** Interim Report, Jul - Aug 1975

Robert D Hayes and Ernest W Coleman 21 Jan 1976 95 p  
 (WR0000101)

(AD-A021311 NADC-75223-20) Avail NTIS CSCL 17/3

An existing computer program which is called the roll plane program was modified. This modification made possible the calculation of the direction of arrival angle from an emitting source. The simulation of a detection scheme which was mounted on an aircraft was a three-element antenna array. Through phase shifting techniques in this array the direction arrival angle was calculated. Author (GRA)

**N76-29217\*** National Aeronautics and Space Administration  
 Ames Research Center, Moffett Field, Calif.

**OBLIQUE-WING SUPERSONIC AIRCRAFT** Patent

Robert T Jones, inventor (to NASA) Issued 27 Jul 1976 19 p Filed 12 Aug 1974 Supersedes N74-30414 (12 - 20 p 2369) Continuation of abandoned US Patent Appl SN-321180, filed 5 Jan 1973, which is a Continuation-in-part of US Patent Appl SN-206279 filed 9 Dec 1971, US-Patent-3,737,121 (NASA-Case-ARC-10470-3 US-Patent-3,971,535 US-Patent-Appl-SN-496779, US-Patent-Class-244-46, US-Patent-Appl-SN-321180 US-Patent-Appl-SN-206279 US-Patent-3,737,121) Avail US Patent Office CSCL 01C

An aircraft including a single fuselage having a main wing and a horizontal stabilizer airfoil pivotally attached at their centers to the fuselage is described. The pivotal attachments allow the airfoils to be yawed relative to the fuselage for high speed flight and to be positioned at right angles with respect to the fuselage during takeoff, landing and low speed flight. The main wing and the horizontal stabilizer are upwardly curved from their center pivotal connections towards their ends to form curvilinear dihedrals. Official Gazette of the U.S. Patent Office

**N76-29218\*#** National Aeronautics and Space Administration  
 Langley Research Center, Langley Station, Va.

**APPLICATION OF ADVANCED TECHNOLOGY TO FUTURE LONG-RANGE AIRCRAFT**

Owen E Schrader 24 May 1976 49 p refs Presented at 35th Ann Conf of the Soc of Allied Weight Engr, Inc., Philadelphia 24-26 May 1976

(NASA-TM-X-73921) Avail NTIS HC \$400 CSCL 01C

An assessment is presented of three separate programs that have incorporated advanced technology into the design of long-range passenger and cargo aircraft. The first technology centers around the use of a span-loaded cargo aircraft with the payload distributed along the wing. The second technology is the application of laminar flow control to the aircraft to reduce the aerodynamic drag. The last program evaluates the production of alternate aircraft fuels from coal and the use of liquid hydrogen as an aircraft fuel. Author

**N76-29221#** Air Force Inst of Tech Wright-Patterson AFB Ohio School of Engineering

**EVALUATION OF F-15 OPERATIONS AND MAINTENANCE COSTS BASED ON ANALYSIS OF CATEGORY 2 TEST PROGRAM MAINTENANCE DATA M S Thesis**

Christopher B Howard Aug 1975 179 p refs

(AD-A021258 GSM/SM/75S-3) Avail NTIS CSCL 15/5

The report contains an analysis of the maintenance data collected as part of the F-15 Category II test program from April 1974 through February 1975 with the intent of updating operations and maintenance cost predictions. A brief review of the Systems Effectiveness Data System is included to provide background on the source of the raw maintenance data. This is followed by an analysis of maintenance man-hours per flight hour (MMH/FM) trends based on regression analysis to determine the expected operational maintenance requirements. Failure data are analyzed to determine system and subsystems reliability. Two reliability models are used for this analysis: an exponential model which assumes a constant instantaneous failure rate and a Weibull model which can represent either an increasing or a decreasing failure rate. GRA

**N76-29222#** Naval Electronics Lab Center, San Diego Calif  
**INTERIM PROGRESS SUMMARY AND DESCRIPTION OF A-7 ALOFT SYSTEM Research and Development Report, Mar 1974 - Dec 1975**

J R Ellis 1 Jan 1976 59 p refs

(WF41X1001 NELC Proj F228)

(AD-A021257 NELC-TR-1968) Avail NTIS CSCL 01/3

The A-7 Airborne Light Optical-Fiber Technology (ALOFT) Demonstration was established to confirm that fiber-optic technology is sufficiently practical and mature to be used in internal aircraft data-signal transmissions and to demonstrate the feasibility of a full A-7 system application. Included are explanations of design tradeoffs that led to the components used in the design of the system. A description of the tests conducted by the Naval Electronics Laboratory Center upon the ALOFT components is provided with a summary of the most significant test results. Graphic and written descriptions of the ALOFT system are included. The test phases yet to be completed are summarized. The economic analysis planned in parallel with the test phase of the project is briefly described. A classification list of the original signals in the A-7 which have been converted from electrical to fiber-optic transmission is provided. GRA

**N76-29223#** Army Aviation Engineering Flight Activity, Edwards AFB, Calif

**PERFORMANCE AND HANDLING QUALITIES EVALUATION AH-1G HELICOPTER WITH LOW REFLECTIVE INFRARED/OPTICAL PAINT Final Report, 27 Nov 1974 - 10 Apr 1975**

A L Winn Robert L Stewart, Edward J Tavares, and Gary L Skinner Aug 1975 53 p refs

(AD-A021407 USAAEFA-75-09) Avail NTIS CSCL 01/3

The performance and handling qualities of an AH-1G helicopter were evaluated in the basic paint configuration, with the fuselage and main and tail rotors painted with a low reflective infrared (IR)/optical paint (FSN 8010-083-6588) and in a modified IR/optical paint configuration in which the tail rotor blades and the main rotor leading edge were stripped of the

IR/optical paint. Flight tests were conducted by the United States Army Aviation Engineering Flight Activity at Edwards Air Force Base, California, between 27 November 1974 and 10 April 1975. Twenty-five flights were flown for a total of 24.7 productive flight hours. Performance testing was limited to hover level flight, and autorotational descent. Handling qualities were qualitatively evaluated throughout the conduct of the test program. Additionally, maneuvering stability was quantitatively evaluated in the IR/optical paint configuration and compared with results from previous reports. GRA

**N76-29224#** Bell Helicopter Co., Fort Worth Tex  
**RESULTS OF BENCH TEST ON ELASTOMERIC OIL SEALS FOR THE UH-1 HELICOPTER TRANSMISSIONS Final Report, Nov 1972 - Jun 1973**

Elias Abraham Dec 1975 48 p refs

(Contract DAAG46-72-C-0143)

(AD-A022321, AMMRC-CTR-75-13) Avail NTIS CSCL 11/1

Two elastomeric oil seal designs, one from Chicago Rawhide and the other from National Seal were bench tested in a UH-1 type main transmission at a surface speed of 9470 fpm. Five samples from each design were tested for five hours each and one sample was tested for 150 hours. Both seal candidate designs performed as well as or better than the baseline production seal tested. Author (GRA)

**N76-29225#** Systems Control, Inc Palo Alto Calif  
**IDENTIFICATION OF T-2 AERODYNAMIC DERIVATIVES FROM FLIGHT DATA Final Report**

D A Buenz S Brooks R Mohr, and J Kanow Mar 1975 112 p refs

(Contract N62269-72-C-0597)

(AD-A021996) Avail NTIS CSCL 01/3

This report presents the stability and control derivatives of a low speed Navy trainer aircraft, the T-2B, as determined from flight test data. The maximum likelihood method is used for the estimation of the aerodynamic derivatives, instrument biases and random errors, and gust effects. The two flight conditions considered are (a) low speed, gear down, flaps deflected sea level, and (b) high speed, gear and flaps up, 10,000 feet altitude. It is shown that it is necessary to include control input bias and in some cases gust effects to get reliable results. Techniques for handling input bias and random noise in input measurement are given. The identified models in each case are verified through several prediction runs. GRA

**N76-29226#** Aeronautical Research Associates of Princeton, Inc, NJ

**SPECTRAL GUST RESPONSE FOR AN AIRPLANE WITH VERTICAL MOTION AND PITCH Final Technical Report, 1 Nov 1974 - 30 Sep 1975**

J C Houbolt and Guy G Williamson Wright-Patterson AFB, Ohio AFFDL Nov 1975 50 p refs

(Contract F33615-75-C-3030)

(AD-A021713 ARAP-256 AFFDL-TR-75-121) Avail NTIS CSCL 01/1

Gust response analysis based upon power spectral techniques is made for an airplane having the two degrees of freedom of vertical motion and pitch. A rather unique formulation of the equations of motion is made, wherein the aerodynamic loads are treated as dependent variables, as are the vertical and pitching motions. Nonsteady lift effects, finite span effects, tail downwash effects, and gust lag effects are all taken into account over the complete frequency range of concern. It is found that the inclusion of pitch considerably alters the response from that found for the case of vertical motion alone. In general, pitch is found to cause a significant attenuation of the response at low frequencies. One of the important findings of the study is the fact that the gust response for the two-degree-of-freedom case can be expressed in a form which is essentially independent of the integral scale of turbulence. Variations in geometric parameters of the airplane, such as tail moment arm, or radius of gyration in pitch, are considered to obtain an idea of the sensitivity of the gust response to these parameters. Author (GRA)

**N76-29227#** RAND Corp Santa Monica Calif  
**PARAMETRIC EQUATIONS FOR ESTIMATING AIRCRAFT  
 AIRFRAME COSTS** Interim Report

J P Large Harry G Campbell and David Cates Feb 1976  
 155 p refs  
 (Contract DAHC15-71-C-0220)

(AD-A022086 R-1693-1-PA/E) Avail NTIS CSCL 01/3

A set of generalized equations for estimating development and production costs of aircraft airframes on the basis of such characteristics as aircraft weight and speed is presented (Extensive investigation has shown that these characteristics explain cost variations better than any other objective parameters.) Equations derived by multiple-regression techniques are presented for each of the major cost elements for total program cost and for prototype development costs. The report explains the derivation of each equation and describes the treatment of the data, the fitting of regression equations, and selection of preferred equations. A detailed numerical example is included which applies to preferred equations and compares the results to those obtained using several sets of alternative equations. Author (GRA)

**N76-29228#** United Technologies Corp Stratford Conn  
 Aircraft Div

**CH-54 OPERATIONAL STATISTICS** Final Report

Robert W Caseria Feb 1976 139 p  
 (Contract DAAJ02-74-C-0064 DA Proj 1F2-62203-AH-8603)  
 (AD-A021692 USAAMRDL-TR-75-51) Avail NTIS CSCL 01/3

The purpose of the CH-54 Operational Statistics program was to validate the CH-54 helicopter in the Army's tactical aircraft reliability and maintainability model and to analyze the results obtained from the factorially designed arrangement of simulation runs on sensitivity credibility and sufficiency. Changes in utilization failure rate NORS waiting time TBO concepts major inspection durations and repair/replacement time distributions were studied. Effects on operational availability intrinsic availability unscheduled elapsed maintenance downtime (including and excluding NORS time) and mission accomplishment were evaluated. A baseline model was established by making successive simulation iterations and refinements until all output statistics tested fell within the allowable statistical range of the expected CH-54B R and M characteristics and operational conditions. GRA

**N76-29231\*#** Hamilton Standard Windsor Locks Conn  
**HAMILTON STANDARD Q-FAN DEMONSTRATOR DYNAM-  
 IC PITCH CHANGE TEST PROGRAM, VOLUME 1** Final  
 Report

W J Demers D J Nelson and H S Wainauski Jul 1975  
 200 p refs 2 Vol  
 (Contract NAS3-18513)  
 (NASA-CR-134861 HSER-6700-Vol-1) Avail NTIS  
 HC \$7 50 CSCL 21E

Tests of a full scale variable pitch fan engine to obtain data on the structural characteristics response times and fan/core engine compatibility during transient changes in blade angle fan rpm and engine power is reported. Steady state reverse thrust tests with a take off nozzle configuration were also conducted. The 1.4 meter diameter 13 bladed controllable pitch fan was driven by a T55 L 11A engine with power and blade angle coordinated by a digital computer. The tests demonstrated an ability to change from full forward thrust to reverse thrust in less than one (1) second. Reverse thrust was effected through feather and through flat pitch structural characteristics and engine/fan compatibility were within satisfactory limits. Author

**N76-29232\*#** Hamilton Standard Windsor Locks Conn  
**HAMILTON STANDARD Q-FAN DEMONSTRATOR DYNAM-  
 IC PITCH CHANGE TEST PROGRAM, VOLUME 2** Final  
 Report

W J Demers D J Nelson and H S Wainauski Jul 1975  
 439 p 2 Vol  
 (Contract NAS3-18513)  
 (NASA-CR-134862 HSER-6700-Vol-2) Avail NTIS  
 HC \$11 75 CSCL 21E

For abstract, see vol 1

**N76-29233\*#** Pratt and Whitney Aircraft East Hartford Conn  
**STUDY OF UNCONVENTIONAL AIRCRAFT ENGINES  
 DESIGNED FOR LOW ENERGY CONSUMPTION** Final  
 Report

D E Gray Jun 1976 142 p refs

(Contract NAS3-19465)

(NASA-CR-135065 PWA-5434) Avail NTIS HC \$6 00 CSCL 21A

Declining US oil reserves and escalating energy costs underline the need for reducing fuel consumption in aircraft engines. The most promising unconventional aircraft engines based on their potential for fuel savings and improved economics are identified. The engines installed in both a long-range and medium-range aircraft were evaluated. Projected technology advances are identified and evaluated for their state-of-readiness for application to a commercial transport. Programs are recommended for developing the necessary technology. Author

**N76-29234\*#** General Electric Co Evendale, Ohio Aircraft  
 Engine Group

**SINGLE STAGE, LOW NOISE, ADVANCED TECHNOLOGY  
 FAN VOLUME 5 FANACOUSTICS SECTION 1 RESULTS  
 AND ANALYSIS**

R R Jutras May 1976 232 p refs

(Contract NAS3-16813)

(NASA-CR-134894) Avail NTIS HC \$8 00 CSCL 21E

The acoustic tests and data analysis for a 0.508-scale fan vehicle of a 111 300 newton (25 000 pound) thrust full-size engine which would have application on an advanced transport aircraft, is described. The single-stage advanced technology fan was designed to a pressure ratio of 1.8 at a tip speed of 503 m/sec (1 650 ft/sec) to achieve the desired pressure ratio in a single-stage fan with low radius ratio (0.38) and to maintain adequate stall margin. The fan has 44 tip-shrouded rotor blades and 90 outlet guide vanes. The two basic approaches taken in the acoustic design were (1) minimization of noise at the source and (2) suppression of the generated noise in the inlet and bypass exhaust duct. Suppression of the generated noise was accomplished in the inlet through use of the hybrid concept (wall acoustic treatment plus airflow acceleration suppression) and in the exhaust duct with extensive acoustic treatment including a splitter. The goal of the design was attainment of twenty effective perceived noise decibels (20 EPNdB) below current Federal Air Regulation noise standards for a full-scale fan at the takeoff cutback and approach conditions. The suppression goal of FAR 36-20 was not reached but improvements in the technology of both front and aft fan-noise suppression were realized. The suppressed fan noise was shown to be consistent with the proposed federal regulation on aircraft noise. Author

**N76-29235#** Tennessee Univ Tullahoma Space Institute  
**INVESTIGATION OF FEASIBLE NOZZLE CONFIGURATIONS  
 FOR NOISE REDUCTION IN TURBOFAN AND TURBOJET  
 AIRCRAFT VOLUME 1 SUMMARY AND SELECTED  
 MULTINOZZLE CONFIGURATIONS** Final Report, Jun  
 1972 - Jul 1975

B H Goethert J R Maus W A Dunnill, and Ingo U Borchers  
 Jul 1975 337 p refs

(Contract DOT-FA72WA-3053)

(AD-A024958/1 FAA-RD-75-162-Vol-1) Avail NTIS  
 HC \$10 00 CSCL 21/5

Techniques for reducing the noise generated by high velocity jet streams exhausting from a wide variety of nozzle configurations were developed. In addition to exploring the techniques for noise suppression and/or redirection emphasis was placed on investigating the physical mechanisms at work in the generation, suppression and redirection of aerodynamic noise. Author

**N76-29236#** Tennessee Univ Tullahoma Space Institute  
**INVESTIGATION OF FEASIBLE NOZZLE CONFIGURATIONS  
 FOR NOISE REDUCTION IN TURBOFAN AND TURBOJET  
 AIRCRAFT VOLUME 2 SLOT NOZZLE CONFIGURATIONS**  
 Final Report, Jun 1972 - Jul 1975

B H Goethert, J R Maus W A Dunnill, Grant T Patterson  
 Mahendra C Joshi, Ken C Shih Daryl W Sinclair Ingo U  
 Borchers and Philip M Yee Jul 1975 339 p refs  
 (Contract DOT-FA72WA-3053)

(AD-A024959/9, FAA-RD-75-162-Vol-2) Avail NTIS HC \$10 00 CSCL 21/5  
For abstract see Vol 1

**N76-29238#** Purdue Univ Lafayette Ind School of Aeronautics, Astronautics and Engineering Sciences  
**FEASIBILITY STUDY OF INITIAL AIRCRAFT PROPULSION SUBSYSTEM INTEGRATION COST MODEL, PHASE 1, PART 1 Final Report, 9 Sep - 31 Dec 1974**  
John W Drake Mostafa R Reda, and James J Allen Jr Oct 1975 65 p ref  
(Contract F33615-74-C-2014 AF Proj 3145)  
(AD-A021075 AA/ES-74-1-Pt-1 AFAPL-TR-75-88-Pt-1) Avail NTIS CSCL 21/5

This report describes two methods of estimating the production costs of jet engines not yet built (1) by building up the costs of the cost driving parts in a traditional Industrial Engineering Fashion and (2) by using regression techniques to estimate either entire engine costs (RAND approach) or parts of engines The report concludes that both methods are feasible though the former has a greater theoretical accuracy Potential problems of accounting for changes in performance and schedule may well give the second method the edge in practical application on the bases of cost speed and speed of implementation GRA

**N76-29239#** Technology Inc, Dayton, Ohio Instruments and Controls Div  
**REPRESENTATIVE ENGINE POWER DATA FOR ARMY HELICOPTERS Final Report, 1 Jul - 1 Sep 1975**  
Terry L Cox Feb 1976 37 p refs  
(Contract DAAJ01-75-C-1051)  
(AD-A022254, TI-073820-75-1 DRS-76-5) Avail NTIS CSCL 21/5

With rapid engine torque pressure changes as the factor of prime interest, some 700 hours of multichannel oscillogram data recorded on AH-1G and UH-1H helicopters while they operated in Southeast Asia and Alaska were reviewed with 54 hours selected and processed to obtain engine power data suitable for the development of criteria for future low-cycle fatigue testing of advanced helicopter engines After short and medium flight lengths were determined a representative flight was selected for each of seven categories of aircraft type geographical location mission type (utility combat assault and combat support) and flight length Four parameters in the seven flights were processed engine torque pressure main rotor speed outside air temperature (OAT) and pressure altitude The intermediate rated power (IRP) limit was computed as a function of OAT and altitude and the engine shaft horsepower was derived from the rotor speed and torque pressure to yield the percent IRP Data presentations include histograms of the flight length frequency distributions time histories of the percent IRP altitude and OAT histograms of the percentage of time in percent IRP ranges and a tabular summary of the 13 torque excursions in the seven flights and related data GRA

**N76-29240\*#** Kanner (Leo) Associates Redwood City, Calif  
**EVOLUTION OF SPIN CHARACTERISTICS WITH AIRCRAFT STRUCTURE**  
J Gobeltz (Lille Inst of Fluid Mechanics France) Washington NASA Aug 1976 40 p Transl into ENGLISH of paper presented at SMP Specialists Meeting Brussels 18-21 Nov 1976 p 14-15  
(Contract NASw-2790)  
(NASA-TT-F-17123) Avail NTIS HC \$4 00 CSCL 01C

Differences in the spin characteristics of the main historical types of aircraft have resulted from structural differences such as increased stabilizer size greater sweep-back and fuselage stretch Specific variables affecting the type of spin of an aircraft are analyzed with reference to a group of 117 military and nonmilitary aircraft of post-1940 design These variables include the effects of the yaw pitch and roll attitude control surfaces flaps slats hatches overall shapes horizontal and vertical stabilizers inertial characteristics and outer loads The modifications of spin occurring in different versions of the same aircraft are discussed in regard to the Mirage III Delta Author

**N76-29241\*#** National Aeronautics and Space Administration Ames Research Center Moffett Field Calif  
**EFFECT OF KRUEGER NOSE FLAPS ON THE EXPERIMENTAL FORCE AND MOMENT CHARACTERISTICS OF AN OBLIQUE WING**  
Edward J Hopkins and George H Lovette Washington Jul 1976 208 p refs  
(NASA-TM-X-3372 A-6362) Avail NTIS HC \$7 75 CSCL 01A

Experimental force and moment data are presented for an oblique wing mounted on a body of revolution and equipped with Krueger type nose flaps The effectiveness of these flaps in making the moment curves more linear by controlling the flow separation on the downstream wing panel at high lift coefficients was determined The investigation of the effects of the Krueger flaps covered two cases (1) use of the flaps on the downstream wing panel only and (2) use of the flaps on both wing panels For part of the tests the Krueger flaps were mounted on nose flaps that were drooped either 5 deg or 10 deg The wing was elliptical in planform had an aspect ratio of 6.0 (based on the unswept span) and was tested at sweep angles of 0 45 deg and 50 deg The Mach-number range covered was from 0.25 to 0.95 It was found that the most effective arrangement of the Krueger flaps for making the pitching-rolling- and yawing-moment curves more linear at high lift coefficients was having the Krueger flaps mounted on the nose flaps drooped 5 deg and only on the downstream wing panel Author

**N76-29242#** Aeronautical Systems Div Wright-Patterson AFB Ohio  
**TERRAIN FOLLOWING CONTROL BASED ON AN OPTIMIZED SPLINE MODEL OF AIRCRAFT MOTION**  
Ph D Thesis  
J E Funk Nov 1975 192 p refs

(AD-A021328 ASD/XR-TR-75-22) Avail NTIS CSCL 01/2  
The major portion of the computational processing of information in an aircraft terrain following system is optimized in order to provide the best commands to the longitudinal flight-control system based on available terrain data Previous terrain-following processors have not optimized the flight path subject to all of the practical constraints The scheme presented incorporates all of the major constraints into an optimization problem that can be solved to provide a reference path for the aircraft to follow The optimal reference path satisfied two important requirements (1) it stays as close to the terrain as possible while satisfying a minimum clearance constraint and the specified acceleration limits and (2) it is a smooth path that the aircraft can follow extremely well by a very simple tracking system The optimization problem is either a quadratic or linear programming problem depending upon the specific closeness performance criterion chosen It appears that it can be solved in real time even for a very high speed missile by an airborne digital computer when accurate vehicle state and terrain information are available The optimal solutions to the problem can also be used as ideal paths to provide standards for evaluating other types of terrain following systems

Author (GRA)

**N76-29243#** Applied Physics Lab Johns Hopkins Univ Laurel Md  
**INVESTIGATIONS RELATED TO THE USE OF ATMOSPHERIC ELECTRIC FIELDS FOR AIRCRAFT AND RPV STABILIZATION**

M L Hill and T R Whyte Jun 1975 253 p refs  
(Contract N00017-72-C-4401)  
(AD-A022051 APL-JHU-TG-1280) Avail NTIS CSCL 01/2  
The atmospheric electric field is oriented vertically or very nearly so over a large fraction of the earth a large fraction of the time Low-cost lightweight rugged electronic devices have been used to sense the electric field and provide a vertical reference for airborne vehicles This report describes some research that has been done to attempt to clarify the performance and practicability of this concept A review of atmospheric electricity is given along with a description of original theoretical and experimental work dealing with the electrostatic sensing system Data obtained during flight tests with an instrumented Cessna Skymaster aircraft are reported The results support the

expectation that there are some limitations associated with weather but it appears that the concept may be useful under a sufficiently wide variety of atmospheric conditions so that improved or new capability in military systems might be achieved by applying this technology to special classes of vehicles GRA

**N76-29244#** Air Force Inst of Tech Wright-Patterson AFB Ohio School of Engineering  
**A DESIGN OF A MODAL CONTROLLER FOR THE B-52 CONTROL CONFIGURED VEHICLE (CCV) M S Thesis**  
 Ronald M Adams Dec 1975 176 p refs  
 (AD-A021872 GE/EE/75D-9) Avail NTIS CSCL 01/3

A large-order multi-input multi-output state-variable model and design specification was recently developed for the B-52 Control Configured Vehicle (CCV) longitudinal axis. This model gives the opportunity to use modern control techniques to design the CCV concepts of interest. Previously the B-52 CCV control task was designed in increments using conventional control techniques. When the entire control problem is formulated and drawn up in one specification however the designers job becomes significantly more difficult. Modern control techniques are available which permit the large multi-input multi-output control problem to be addressed. For this thesis modal control theory is applied to the B-52 CCV state-variable model. The pertinent theory is presented and then a multi-stage design procedure is applied. GRA

**N76-29245#** Advisory Group for Aerospace Research and Development Paris (France)  
**STALL/SPIN PROBLEMS OF MILITARY AIRCRAFT**  
 Jun 1976 242 p refs Presented at the Flight Mech Panel Specialists Meeting Rhode Saint Genese Belgium 18-21 Nov 1975  
 (AGARD-CP-199) Avail NTIS HC \$8 00

Stall/spin aspects of aircraft design are discussed in relation to the high angle of attack problem

**N76-29246** Air Force Flight Dynamics Lab Wright-Patterson AFB Ohio  
**THE STALL/SPIN PROBLEM**  
 Robert J Woodcock and Robert Weissman (ASD) In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 12 p refs

Stall/spin problems still plague aircraft designers. The development of spin tunnel and free flight model testing techniques is traced. Prospects of improved aerodynamics are indicated and some flight control system capabilities outlined with reference to experience with some recent airplanes. Recovery from spins and post-stall gyrations is emphasized but a need for more emphasis on designing for resistance to loss of control is advocated. Author

**N76-29247** General Dynamics/Fort Worth Tex  
**THE STALL/SPIN PROBLEM - AMERICAN INDUSTRY'S APPROACH**  
 Charles A Anderson In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 8 p

An attempt is made to detail what has caused stall/spin problems. What options are open to the aircraft designer to reduce stall/spin susceptibility and some of the current evaluation criteria that are available. Also the various analytical and experimental tools and flight test techniques available today are reviewed. An assessment is then made of the usefulness of each of these guidelines, tools, and techniques. Finally, a recommended procedure for determining the stall/spin susceptibility and characteristics is presented. Author

**N76-29248** Aeroplane and Armament Experimental Establishment Boscombe Down (England)  
**COMPARISON OF THE SPIN AND LOW INCIDENCE AUTOROTATION OF THE JAGUAR STRIKE AIRCRAFT**  
 R J Blamey In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 10 p refs

From the extensive flight trials on Jaguar high incidence and spin behavior a number of interesting results emerged.

Compared is the classical high incidence spin mode with a rather less common low incidence autorotation which appeared during Jaguar evaluation trials. Author

**N76-29249** British Aircraft Corp Preston (England)  
**A COMPARISON OF MODEL AND FULL SCALE SPINNING CHARACTERISTICS ON THE LIGHTNING**  
 B R A Burns In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 12 p

Lightning spinning history is reviewed and a comparison is made of the characteristics as shown by vertical wind tunnel helicopter drop model and full scale flight trials. The comparison is made in terms of both qualitative interpretation of the spin and recovery behavior and measured data. It is shown that the three types of tests exhibited good qualitative agreement in all important respects. Only a limited quantitative comparison is possible because of limitations of the measured data and differences between the test techniques. The test results are related to service experience and some observations are made about the interpretation of spinning test results and the need for simplicity in pilot's operating notes. Author

**N76-29250** Northrop Corp Hawthorne Calif  
**DESIGN TECHNOLOGY FOR DEPARTURE RESISTANCE OF FIGHTER AIRCRAFT Aircraft Div**  
 A Titiriga Jr J S Ackerman and A M Skow In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 13 p refs

Methods are presented for predicting departure characteristics of aircraft during the design stages prior to model or flight tests. The significance of longitudinal pitching moment characteristics with respect to sideslip is discussed and correlated with flight test data. The use of departure parameters is discussed and examples are presented which show good correlation with flight test results. A computer graphics display of the aircraft driven by actual flight test data has proven to be extremely helpful in visualizing complex motions of an aircraft. In particular this technique shows great promise in aiding both pilots and engineers in describing disorienting post stall gyrations that may be encountered during stall/spin flight testing of an aircraft. Author

**N76-29251\*** National Aeronautics and Space Administration Langley Research Center Langley Station Va  
**RESULTS OF RECENT NASA STUDIES ON SPIN RESISTANCE**  
 Joseph R Chambers William P Gilbert and Sue B Grafton In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 12 p refs  
 CSCL 01C

Some of the factors which contribute to good stall/spin characteristics of a current fighter configuration indicate that the design of airframe components for inherent spin resistance is very configuration dependent and that few generalizations can be made. Secondary design features, such as fuselage forebody shape, can have significant effects on stability characteristics at high angles of attack. Recent piloted simulator studies and airplane flight tests have indicated that current automatic control systems can be tailored so as to provide a high degree of spin resistance for some configurations without restrictions to maneuverability. Such systems result in greatly increased pilot confidence and increased tactical effectiveness. Author

**N76-29252** Institut de Mecanique des Fluides de Lille (France)  
**APPLICATION OF STATIC AND DYNAMIC AERODYNAMIC COEFFICIENTS TO THE MATHEMATICAL CORRELATION OF WIND TUNNEL TEST RESULTS ON AIRCRAFT SPINS [APPLICATION DES MESURES DE COEFFICIENTS AERODYNAMIQUES STATIQUES ET DYNAMIQUES A DES RECOUPEMENTS PAR CALCUL DES VILLES OBTENUES EN SOUFFLERIE]**  
 Marc Vanmansart In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 9 p In FRENCH

A conventional light aircraft model with efficient control surfaces and comparatively easy spin characteristics was used to validate the modelling of spin maneuvers by correlating vertical

wind tunnel results with static and dynamic aerodynamic coefficients. It was first concluded that these coefficients must be measured while the aircraft is in continuous rotation; these measurements must take into account the efficiency of the control surfaces which is itself strongly affected by the general flow pattern and are only applicable to the case of comparatively mild spins. In the case of modern military aircraft, however, spins are usually more complex and violent, and measurements of forced oscillations while the model is in continuous rotation should presumably be included. Transl. by Y J A

**N76-29253** Aeronautica Macchi S p A Varese (Italy)  
**STALL BEHAVIOR AND SPIN ESTIMATION METHOD BY USE OF ROTATING BALANCE MEASUREMENTS**  
Ermanno Bazzocchi / In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 16 p

Experimental work is reported in the field of wind tunnel investigation of stall behavior in the evaluation of the characteristics of lateral control devices, in the measurement of the aerodynamic coefficients to determine lateral-directional stability and the analytical study of the spin. This research has required the development of special test equipment, measurement methods and calibration systems. A description and data is given on the test equipment adopted, its use and some of the results obtained. Author

**N76-29254** Ghent Univ (Belgium)  
**STABILITY OF HELICOIDAL MOTIONS AT HIGH-INCIDENCES**

F C Haus / In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 20 p

Mathematical solutions are found for three kinds of problems: (1) to compute the equilibrium condition of steady motion when the aircraft follows a helicoidal descending path around a vertical axis; (2) to establish the linear equations governing perturbations about the steady state and to determine the characteristic modes of the resulting motion; and (3) to integrate the nonlinear equations of motion and to determine the manner in which an aircraft can reach a steady state motion or depart from it - (entry into or recovery from a spin). Such mathematical operations provide insight into the mechanics of spinning motion even though aerodynamic coefficients are not known very accurately at the present time. Author

**N76-29255** Institut de Mecanique des Fluides de Lille (France)  
**EFFECTS OF AIRFRAME DESIGN ON SPIN CHARACTERISTICS [EVOLUTION DES CARACTERISTIQUES DE LA VRILLE EN FONCTION DE L'ARCHITECTURE DES AVIONS]**

Jean Gobeltz / In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 15 p In FRENCH

The effects of changes in the airframe geometry during the last few decades on aircraft spin characteristics were reviewed. The type of aircraft considered ranged from low speed, pre-world war II, propeller driven aircraft through the early jet aircraft with moderate sweepback to the most recent jet aircraft with pronounced sweepback. The contribution of the various airframe components such as control surfaces, flaps, airbrakes, fins, fuselage, wings, etc was discussed in addition to other relevant factors such as inertial characteristics, external loads, rockets, etc. Special emphasis was placed on the Mirage 3 and Lightning aircraft. Y J A

**N76-29256** Air Force Flight Dynamics Lab Wright-Patterson AFB, Ohio

**LIMITING FLIGHT CONTROL SYSTEMS**

David K Bowser / In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 12 p refs

The development and application of various types of automatic flight control systems for high angle of attack augmentation and limiting are reported. Considerations included are improved handling qualities for maximum tracking effectiveness, reduced pilot workload, control configured vehicles, stall inhibitors and departure prevention systems. Author

**N76-29257\*** National Aeronautics and Space Administration Ames Research Center Moffett Field Calif

**ASYMMETRIC AERODYNAMIC FORCES ON AIRCRAFT AT HIGH ANGLES OF ATTACK - SOME DESIGN GUIDES**

Gary T Chapman, Earl R Keener and Gerald N Malcolm / In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 9 p refs

CSCAL 01A

Aerodynamic side forces on forebodies are considered that are produced by two types of flow asymmetric vortices on bodies of revolution and nonuniform flow separation on square bodies with rounded corners under spinning conditions. Steady side forces that can be as large as the normal force are produced by asymmetric vortices on pointed forebodies. This side force has a large variation with Reynolds number, decreases rapidly with Mach number and can be nearly eliminated with small nose bluntness or strakes. The angle of attack where the side force first occurs depends primarily on body geometry. The theoretical techniques to predict these side forces are necessarily semi-empirical because the basic phenomenon is not well understood. The side forces produced by nonuniform flow separation under spinning conditions depend extensively on spin rate, angle of attack and Reynolds number. The application of simple crossflow theory to predict this side force is inadequate much below angles of attack of 90 deg. Author

**N76-29258\*** National Aeronautics and Space Administration Langley Research Center Langley Station, Va

**STALL/SPIN TEST TECHNIQUES USED BY NASA**

Joseph R Chambers, James S Bowman Jr and Gerald N Malcolm (NASA Langley) / In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 12 p refs

CSCAL 01C

Unique test techniques and facilities are reported which are used to predict the stall/spin characteristics of highly maneuverable military aircraft. Three of the more important test techniques are: (1) flight tests of dynamically scaled models, (2) rotary balance tests and (3) piloted simulator studies. Recent experience has indicated that the extension of piloted simulation techniques to high angles of attack provides valuable insight as to the spin susceptibility of fighter configurations during representative air combat maneuvers. In addition, use of the technique is an effective method for the development and evaluation of automatic spin prevention concepts. Author

**N76-29259** Institut de Mecanique des Fluides de Lille (France)  
**EFFECTS OF STATIC MOMENTS FROM ROCKETS OR ASYMMETRIC LOADS ON AIRCRAFT SPINS [ACTION SUR LA VRILLE, PAR MOMENT STATIQUE, DE FUSEES ET DE CHARGEMENTS DISSYMETRIQUES]**

Jean Gobeltz and Lucien Beaurain / In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 11 p refs In FRENCH

Vertical wind tunnel test results performed on different scale models to investigate aircraft spin maneuvers were discussed. Two areas were considered: (1) the use of rockets carried on aircraft to be fired as an emergency device during spins. The application of this concept has so far been limited to light aircraft, although certain qualitative conclusions may be valid for other types of aircraft including military aircraft; (2) the influence of asymmetrical loads on spins for aircraft of all types: military, light transport. In the case of military aircraft, geometrical asymmetries were also discussed. Transl. by Y J A

**N76-29260** Centre d'Essais en Vol, Bretigny-sur-Orge (France)  
**A NEW ANALYSIS OF SPIN, BASED ON FRENCH EXPERIENCE ON COMBAT AIRCRAFT [UNE NOUVELLE ANALYSE DE LA VRILLE BASEE SUR L'EXPERIENCE FRANCAISE SUR LES AVIONS DE COMBAT]**

Claudius LaBurthe / In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 9 p In FRENCH ENGLISH summary

Relatively few aircraft are lost owing to sinking, stalling or

spinning Among other reasons this favorable result may be attributed to a particular emphasis put on pilot instruction about aircraft behavior at high angles of attack But in view of the unfavorable influence of wing loading this situation might deteriorate with new aircraft Some test results are analyzed as regards the nature of losses of control The major influence of inertia is thus demonstrated Limits of credibility for stall warning systems based upon angle of attack measurement, are then deduced  
Author

**N76-29261** Messerschmitt-Boelkow-Blohm G m b H Hamburg (West Germany)

**SPIN INVESTIGATION OF THE HANSA JET**

Herbert Neppert /In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 7 p refs

Spin characteristics of the Hansa jet from calculation, vertical spin tunnel and flight have been compared As a result of the superstall a special form of flat spin with low rate of rotation is obtained An analysis is carried out and various recovery methods are given  
Author

**N76-29262** Avions Marcel Dassault-Breguet Aviation Saint-Cloud (France)

**FLIGHT TEST METHODS FOR THE STUDY OF SPINS [METHODES D'ESSAIS DE VRILLES EN VOL]**

J P Duval /In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 9 p In FRENCH

A system of instruments and techniques developed to investigate aircraft spin maneuvers was described Both ground-based systems (telemetry real-time and delayed-time measurements) and airborne systems (instrument management, cameras, etc.) are described and discussed The Alpha-Jet aircraft is used as an example to illustrate the technique used including the importance of preliminary wind tunnel test results and the subsequent logical sequence of flight tests Recent flight test results were illustrated  
Transl by Y J A

**N76-29263** Grumman Aerospace Corp Calverton NY

**F-14A STALL SPIN PREVENTION SYSTEM FLIGHT TEST**

Charles A Sewell and Raymond D Whipple /In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 7 p refs

The evaluation of various spin prevention design concepts for the F-14 Tomcat by analytical simulational and experimental methods is described Preparation of the test vehicle is detailed showing unique emergency systems and qualification testing of these systems Operational aspects of the flight test program including the problem devising a system flexible enough to permit in-flight optimization of design parameters is treated The gradual shift in emphasis from spin prevention which was accomplished with relative ease, to departure amelioration for enhanced air combat effectiveness is documented An overview of the final ARI with associated subsystems is given  
Author

**N76-29264** Avions Marcel Dassault-Breguet Aviation Saint-Cloud (France)

**SPIN FLIGHT TEST OF THE JAGUAR, MIRAGE F1 AND ALPHA-JET AIRCRAFT [ESSAIS DE VRILLES DU JAGUAR, DU MIRAGE F1 ET DE L'ALPHA-JET]**

J Differ J P Duval and J Plessy /In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 6 p In FRENCH

A series of flight tests designed to investigate spin characteristics on the following aircraft were described Jaguar Mirage F1 and Alpha-Jet The case of the Alpha-Jet is especially interesting in view of its training role Results obtained during these tests were described and compared to wind tunnel tests predictions  
Transl by Y J A

**N76-29265** General Dynamics/Fort Worth Tex

**YF-16 HIGH ANGLE OF ATTACK TEST EXPERIENCE**

John P Lamers /In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 14 p

The objective of high angle of attack flight tests was to clear the aircraft for the air combat maneuvering test phase

This was to be accomplished by validation of predicted aerodynamic data and a comprehensive evaluation of handling qualities and flight control system performance during aggressive simulated tactical maneuvering The program also included a realistic evaluation of the effectiveness of special automatic control system features designed to enhance high angle of attack maneuverability, handling qualities and departure resistance Of particular interest were the effects of the active control system (command and stability augmentation) and relaxed static stability concepts upon stall/spin characteristics and recovery capability Engine operating characteristics at high angle of attack high angle of sideslip, low airspeed conditions were also of interest Results show excellent high angle of attack flight characteristics good correlation with NASA spin model results, and normal flight control system operation over the range of conditions tested  
Author

**N76-29266** Naval Air Systems Command Washington D C  
**US NAVY FLIGHT TEST EVALUATION AND OPERATIONAL EXPERIENCE AT HIGH ANGLE OF ATTACK**

Alexander F Money and Donald E House (Naval Air Test Center) /In AGARD Stall/Spin Probl of Mil Aircraft Jun 1976 10 p refs

An overview is presented of the problem areas presently considered most significant in the high angle of attack flight regime in U S Navy aircraft The U S Navy philosophy of high angle of attack flight testing is also discussed with examples of some of the more recent programs  
Author

**N76-29268\*** National Aeronautics and Space Administration Ames Research Center Moffett Field Calif

**ANALYTICAL MODELS FOR ROTOR TEST MODULE, STRUT, AND BALANCE FRAME DYNAMICS IN THE 40 BY 80 FT WIND TUNNEL**

Wayne Johnson Jun 1976 18 p refs Prepared in cooperation with Army Air Mobility R and D Lab, Moffett Field Calif (NASA-TM-X-73153 A-6692) Avail NTIS HC \$3 50 CSCL 14B

A mathematical model is developed for the dynamics of a wind tunnel support system consisting of a balance frame struts and an aircraft or test module Data are given for several rotor test modules in the Ames 40 by 80 ft wind tunnel A model for ground resonance calculations is also described  
Author

**N76-29276\*** Air Force Systems Command Wright-Patterson AFB, Ohio Foreign Technology Div

**COMPARISON OF TWO- AND THREE-DIMENSIONAL TRANSONIC TESTS MADE IN VARIOUS LARGE WIND TUNNELS**

Xavier Vaucheret, Maurice Brazin and Claude Armand 10 Feb 1976 42 p refs Transl into ENGLISH from Office National d Etudes et de Recherches Aérospatiales (France) no 1 1975 p 11-114

(AD-A021348 FTD-IDRSI-0068-76) Avail NTIS CSCL 14/2

A critical study is reported of testing conditions at transonic speeds and of the validity of the data obtained in various Wind-Tunnels In two dimensional flow two models of NACA 0012 and supercritical profiles have been tested as well as three homothetical profiles of NACA 0012 In three dimensional flow four homothetical models of a typical transport aircraft were successively tested in twelve transonic tunnels commonly used for development tests in various countries The data are compared in a broad range of Reynolds number (0.3 to 7 millions) between Mach number 0.7 and 0.96  
GRA

**N76-29279\*** Aeronautical Systems Div Wright-Patterson AFB, Ohio Deputy for Development Planning

**AIR FORCE MASTER PLAN - SIMULATORS FOR AIRCREW TRAINING Final Report**

D S Dunlap and Richard E Worthey Dec 1975 55 p refs (AD-A021576 ASC/XR-TR-75-25) Avail NTIS CSCL 14/2

The application of simulators for aircrew training in the United States Air Force is addressed Major operating commands provided current and projected requirements for aircrew training simulators

for incorporation into formal training programs together with estimates of their impact on flight training. A simulator technology overview is provided and a technology research program is proposed to support future acquisitions. Estimates of program costs are made and the magnitude of potential direct operating costs and fuel savings are presented for each of the acquisition programs. Institutional and management problems are also addressed. GRA

**N76-29281#** Battelle Columbus Labs. Ohio. Tactical Technology Center.

**FEASIBILITY OF A NAP-OF-THE-EARTH TRAINER USING A QH-50D REMOTELY PILOTED HELICOPTER AND SYNTHETIC FLIGHT TRAINING SYSTEM. Final Report.** D W Welp, A S Chace and F A Tietzel. Dec 1975. 78 p. refs.

(Contract DAAH01-73-C-0142. ARPA Order 2238).

(AD-A022025). Avail. NTIS. CSCL 01/3.

The objective of the study was to examine the technical and cost feasibility of using a television instrumented remotely piloted helicopter (RPH) as part of a closed-loop helicopter crew. Nap-of-the-Earth flight training system coupled with a Synthetic Flight Training System. The study analyzed and determined the visual display motion system and computational (hardware and software) requirements for the SFTS. Requirements for the RPH airframe and avionics were developed. Evaluation of the QH-50D determined that it had sufficient performance capabilities to serve as the RPH. GRA

**N76-29284#** Cadre Corp. Atlanta, Ga.  
**AIR FORCE AERO PROPULSION LABORATORY COMPONENT TEST AIR FACILITY STUDY. Final Report. 20 May 1974 - 20 Jun 1975.**

Nick H. Primm and King McMullen. Wright-Patterson AFB. Ohio. AFAPL. Oct 1975. 302 p.

(Contract F33615-74-C-2032. AF Proj 1997).

(AD-A020140. AFAPL-TR-75-56). Avail. NTIS. CSCL 14/2.

This report summarizes the study to analytically develop the design criteria, performance specifications, and operation and maintenance philosophies for an expanded Component Test Air Facility capable of supporting current and anticipated Air Force aero-propulsion RDT and E requirements at the Air Force Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio. The report also contains a complete estimate of the cost for expanding the facility and a work flow diagram for accomplishing this expansion with minimal disruption to RDT and E programs. GRA

**N76-29287#** Advisory Group for Aerospace Research and Development. Paris (France).

**FLIGHT SIMULATION/GUIDANCE SYSTEMS SIMULATION.**

Jun 1976. 380 p. refs. Presented at the Joint Flight Mech Panel/Guidance and Control Panel Symp. The Hague. 20-23 Oct 1975.

(AGARD-CP-198). Avail. NTIS. HC \$1075.

Papers are presented dealing with the use of flight simulation techniques. Specific topics discussed include (1) approach and blind landing, (2) aircraft design, and (3) military operations and missions such as air combat, weapon delivery, and mission training. The generation of motion visual and feel cues and turbulence models are also discussed.

**N76-29288** British Aircraft Corp. Warton (England). Military Aircraft Div.

**THE GROWING CONTRIBUTION OF FLIGHT SIMULATION TO AIRCRAFT STABILITY, CONTROL AND GUIDANCE PROBLEMS.**

A G Barnes. In AGARD Flight Simulation/Guidance Systems Simulation. Jun 1976. 13 p. refs.

The changing role and contribution of the research/development simulator is discussed. It is a field of activity where rapid progress is being made and the reasons for such progress are considered. In particular the advances which developments

in TV based displays have brought are noted. Examples are given of the increasing range of problems now addressed on simulators and some of the future trends are indicated. Author.

**N76-29289** Messerschmitt-Boelkow-Blohm G m b H., Munich (West Germany). Human Engineering Dept.  
**A METHOD FOR THE GUIDANCE AND CONTROL SYSTEM EVALUATION FROM THE OPERATIONAL POINT OF VIEW.**

H Denkscherz and P Hahn. In AGARD Flight Simulation/Guidance Systems Simulation. Jun 1976. 7 p.

A method is described for human engineering assessment of avionic systems. The method is based on the use of human engineering criteria for which examples are given. The way these criteria lead to system evaluation and system optimization is shown by examples. Author.

**N76-29290** Centre d'Essais en Vol. Istres (France).  
**INVESTIGATION OF THE LANDING APPROACHES FOR A STOL AIRCRAFT USING A FLIGHT SIMULATOR. [ETUDE AU SIMULATEUR DU PILOTAGE D'UN AVION STOL EN APPROCHE].**

J P Petit and J C Raynal (ONERA, Modane). In AGARD Flight Simulation/Guidance Systems Simulation. Jun 1976. 15 p. In FRENCH. ENGLISH summary.

The influence of instrumentation in the establishment of longitudinal handling qualities criteria for approach and flare was investigated. Velocity vector head-up display IFR and VFR instrumentation were tested. Various types of STOL aircraft were defined by modification of the engine thrust static and dynamic characteristics and by modification of the lift coefficients in order to give them various flight path margins and various flight path rates of change. The simulation methods used to define several STOL aircraft, the test program conducted, and the results obtained are described. Author.

**N76-29291** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt. Brunswick (West Germany). Inst fuer Flugfuehrung.

**THE USE OF A FLIGHT SIMULATOR IN THE SYNTHESIS AND EVALUATION OF NEW COMMAND CONTROL CONCEPTS.**

R Onken, V Adam and R Dierke. In AGARD Flight Simulation/Guidance Systems Simulation. Jun 1976. 16 p. refs.

The introduction of digital electric flight control systems as well as new theoretical techniques in optimal control open new ways in overall design. In particular the development of advanced command control systems offers great promise. A flight simulator is used as a design aid and as a means for exploratory and comparative investigations for the study of flight path command systems. Some results show the tracking performance achieved with an optimized control law and suitably modified pilot interfaces. Author.

**N76-29292** Naval Air Development Center. Warminster, Pa. Air Vehicle Technology Dept.

**APPLICATION OF FLIGHT SIMULATION TO DEVELOP, TEST, AND EVALUATE THE F-14A AUTOMATIC CARRIER LANDING SYSTEM.**

Robert L Fortenbaugh and James M Rebel (NATC). In AGARD Flight Simulation/Guidance Systems Simulation. Jun 1976. 13 p. refs.

In the development of a F-14A automatic carrier landing system, a moving-base simulator was utilized to replace portions of both computerized synthesis and flight test phases. The simulator proved to be a cost effective test and evaluation tool in that it was able to duplicate and predict flight test results to receive pilot acceptance as a valid representation of the real airplane and to provide significant increases and flexibility in the number of parameter combinations that could be examined by a pilot. Author.

**N76-29293** Societe Nationale Industrielle Aerospatiale. Toulouse (France). Dept des Etudes de Qualites de Vol et de Pilotage.



**SIMULATION TECHNIQUES AND METHODS USED FOR THE STUDY AND ADJUSTMENT OF THE AUTOMATIC LANDING SYSTEM ON THE CONCORDE SUPERSONIC TRANSPORT AIRCRAFT [MOYENS ET METHODES DE SIMULATION UTILISEES POUR L'ETUDE ET LA MISE AU POINT DE L'ATTERRISSAGE AUTOMATIQUE DE L'AVION DE TRANSPORT SUPERSONIQUE CONCORDE]**

Raymond Deque and Jean-Louis Bonafe *In* AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 11 p *In* FRENCH

After a brief presentation of flight simulation techniques, the utilization of the automatic landing system of the Concorde breakdown consequences and performance analysis are studied. A critical test of turbulence models is presented in the effective analysis of turbulences encountered in flight tests.

Transl by B B

**N76-29294 Boeing Aerospace Co Seattle Wash  
USE OF THE FLIGHT SIMULATOR IN YC-14 DESIGN**

Robert E Spitzer *In* AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 14 p refs

The twin-engine USAF/Boeing YC-14 STOL prototype is approaching the final stages of fabrication and assembly. With upper-surface-blowing powered lift and triplex digital flight control system the YC-14 represents a new generation of transport aircraft. The piloted flight simulator has served as an integral tool in the design process. The flight simulation work that supported and guided YC-14 development is described. Organization and features of the digital math model are discussed. The simulation includes powered-lift effects, engine bleed for leading edge BLC, mechanical and electrical flight control systems, aerial delivery modes, and a newly developed wind and turbulence model. The three main contributions of the simulator are covered: criteria development, control system definition and validation of flying qualities. Criteria for engine-out STOL approach are discussed. Control laws were developed for conventional piloting techniques for STOL speed and flight path control. Satisfactory flying qualities were validated by Boeing USAF, and NASA pilots for a wide range of flight conditions. It is concluded that the flight simulator is an invaluable tool in the design of advanced technology aircraft such as the YC-14.

Author

**N76-29295\* Kansas Univ Lawrence  
SIMULATION AND SIMULATOR DEVELOPMENT OF A SEPARATE SURFACE ATTITUDE COMMAND CONTROL SYSTEM FOR LIGHT AIRCRAFT**

Jan Roskam *In* AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 15 p refs. Sponsored by NASA

**CSSL 14B**

A detailed description is presented of the simulation philosophy and process used in the development of a Separate Surface Attitude Command control system (SSAC) for a Beech Model 99 Airliner. The intent of this system is to provide complete three axes stability augmentation at low cost and without the need for system redundancy. The system, although aimed at the general aviation market, also has applications to certain military airplanes as well as to miniature submarines.

Author

**N76-29296 Messerschmitt-Boelkow-Blohm GmbH Munich (West Germany)**

**BENEFITS OF FLIGHT SIMULATION WORK FOR THE DEFINITION, LAYOUT, AND VERIFICATION WITH HARDWARE IN THE LOOP, OF THE MRCA FLIGHT CONTROL SYSTEM**

W Burkhardt, E Zehner, and W Duerr *In* AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 20 p

Based on the description of the Primary Flight Control System of the MRCA, the main system layout parameters are explained. The main benefits of software system simulation and layout are pointed out and their test results are illustrated. The subsequent hardware system integration work on a Flight Control Test Rig with open loop tests and closed loop tests combined with the computer aircraft simulation are demonstrated.

Author

**N76-29297 Air Force Flight Test Center Edwards AFB Calif  
SIMULATION IN SUPPORT OF FLIGHT TEST**

Richard R Hansen, Christopher J Nagy, and Paul W Kirsten *In* AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 28 p

The General Purpose Engineering Simulator (GPES) operated by the Air Force Test Center to support conventional aircraft and aerospace vehicle testing and developmental engineering is described. The GPES is a small simulator without motion or visual systems for somatic cueing. Two concurrent real-time man-in-the-loop simulations are provided by this system which includes hybrid and analog computers. This system is used in aircraft design modification, pilot familiarization, handling qualities investigations, and accident investigations among other engineering studies. A simple but accurate simulator such as the GPES has many advantages in an aircraft testing environment over more complex systems with motion and visual cues.

Author

**N76-29298 Naval Air Development Center Warminster, Pa  
Air Vehicle Technology Dept  
A JOINT PILOT/LANDING OFFICER SIMULATION PERFORMED TO DETERMINE AIRCRAFT WAVE-OFF PERFORMANCE REQUIREMENTS**

Ronald L Nave *In* AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 10 p refs

A combined pilot/landing signal officer simulation was performed at the Naval Air Development Center in order to develop requirements for the wave-off performance of Naval aircraft. The simulator was also used to investigate the dynamic interaction between the pilot and landing signal officer. Thrust/weight ratio and wing loading were identified as being the most important aircraft parameters influencing wave-off performance. A wave-off performance requirement was developed which specified minimum values of aircraft normal acceleration as a function of trim airspeed and time after initiation of the wave-off maneuver. A minimum thrust/weight ratio of 4 and a maximum power approach wing loading of 90 lb/sq ft were recommended based on pilot opinion gathered in the simulation. In a separate LSO experiment it was determined that the landing signal officer could detect aircraft altitude errors during approach as small as 5 feet at 1/4 mile range.

Author

**N76-29299 Naval Air Test Center Patuxent River Md  
ON IMPROVING THE FLIGHT FIDELITY OF OPERATIONAL FLIGHT/WEAPON SYSTEM TRAINERS**

Marle D Hewett and R Thomas Galloway *In* AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 13 p refs

A team approach utilizing the complementary talents and expertise of Naval test pilots, flight test engineers, computer specialists, and simulator specialists from various Naval field activities is described. The approach is effective in improving the flight fidelity of existing Operational Flight Trainers and Weapon System Trainers and in guiding contractors in providing the best fidelity possible in new flight simulators. Results obtained in several programs are presented.

Author

**N76-29301 Ecole Nationale Supérieure de l'Aéronautique et de l'Espace, Toulouse (France)**

**SIMULATION OF A VISUAL AID SYSTEM USED FOR THE PILOTING OF HELICOPTERS IN FORMATION FLYING**

J H Liereus, A J Fossard, M Clieue (Centre d'Etudes et de Recherches Toulouse) and N Imbert (Centre d'Etudes et de Recherches Toulouse) *In* AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 14 p refs *In* FRENCH

Real time simulation of a system used to aid the piloting of a helicopter, permitting it to fly in formation in hazardous weather conditions is presented. The leader arranges the navigation paths, the crew plots the distance and level of the preceding helicopter with the aid of a radar detection system. The simulation introduces the requirement of a human pilot who, with the help of a micromanipulator, provides orders of cyclic paths longitudinal

and lateral, determining the evolutions of a helicopter crew stationed at a digital computer Transl by B B

**N76-29302** Forschungsinstitut fuer Anthropotechnik Meckenheim (West Germany)

**THE INFLUENCE OF VISUAL EXPERIENCE AND DEGREE OF STYLIZATION ON HEIGHT AND DISTANCE JUDGEMENT IN AIRCRAFT APPROACH SCENES**

Gert Doerfel / In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 9 p refs

The technical development of the visual system of a flight simulator is considered. The basic problem is to determine to what extent the external scene might be simplified and stylized while still presenting enough of the required information to the pilot for the landing approach. Experimental results which help to establish the human engineering visual requirements for the visual simulator being developed are given. Author

**N76-29303** Royal Aircraft Establishment Bedford (England)  
**DIGITALLY GENERATED OUTSIDE WORLD DISPLAY OF LIGHTING PATTERN USED IN CONJUNCTION WITH AN AIRCRAFT SIMULATOR**

J C Penwill / In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 12 p refs

The main features are described of a digitally generated outside world display along with its uses as part of a flight simulation facility to support research programs concerned with all weather operations. The picture presented to the pilot is a view of airfield approach and runway lights as seen at night. The view is collimated to infinity by the use of a simple low cost concave mirror and can be seen by all crew members on the fixed base cockpit. The basis of the system is a digital computer used to generate the perspective picture and a specially developed television camera using a frame sequential technique which, together with a modified monochrome projector presents a color display to the pilot. The system provides a very cost effective simulation of low visibility conditions. Author

**N76-29304** National Aerospace Lab Amsterdam (Netherlands)  
**DESIGN AND PERFORMANCE OF THE FOUR-DEGREE-OF-FREEDOM MOTION SYSTEM OF THE NLR RESEARCH FLIGHT SIMULATOR**

W P Koeversmans and C J Jansen / In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 11 p

The motion system of the NLR research flight simulator with freedom of motion in heave roll pitch and yaw is described. To give good motion cues smooth operation without any jerks is required. To this end specific hydraulic jacks were developed in which stick-slip phenomena are eliminated by introducing hydrostatic bearing between the moving piston and rod and the fixed cylinder resulting in an acceleration threshold level below 0.01 g. A mathematical model was prepared to simulate and study the behavior of the hydraulic jacks. Results are given of measurements on single jacks and the complete system comprising acceleration noise and threshold level, dynamic response and performance diagrams. Because of the required oil pressure for the hydrostatic bearing special procedures have to be followed to start and stop the operation of the system. A description is given of the principles of the safety system applied. Author

**N76-29305** Cranfield Inst of Technology (England) Dept of Electronic and Control Engineering  
**FEEL FORCE SYSTEM WITH AN INERTIA REDUCTION CAPABILITY**

J M Lipscombe and D J G Lewis / In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 13 p refs

The design construction and test of a single and twin stick feel force system is described. The systems have the usual variable feel characteristics of stiffness damping backlash Coulomb friction and breakout force and also a variable inertia so that the effective inertia can be increased to more than the stick

inertia or reduced to a small proportion of the stick inertia. Parameter plane design techniques are applied to a high order mathematical model of the system and a digital computer and visual display unit are used in interactive mode to evaluate and plot the locus of the parameters of the system for any desired pole and zero locations on the s-plane. The performance of the model is then compared to the performance of the system under test. Author

**N76-29306** Royal Aircraft Establishment, Bedford (England)  
**Flight Systems Dept**

**DEVELOPMENTS IN THE SIMULATION OF ATMOSPHERIC TURBULENCE**

B N Tomlinson / In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 14 p refs

In ground-based simulation of aircraft flight inclusion of atmospheric turbulence is essential to the successful evaluation of handling and ride qualities and to the creation of a realistic subjective environment and representative pilot workload. A new model of atmospheric turbulence capable of generating time-histories which reproduce the essential discrete-gust and non-Gaussian features of turbulence is described. A principal aim of the model is to reproduce the quality of intermittency identified in real atmospheric turbulence from the non-Gaussian distributions of velocity differences. Qualitatively, intermittency appears in a turbulence record as relatively isolated large changes in gust velocity embedded in a background of low activity. Comparison with flight measurements of atmospheric turbulence shows that power spectra intermittency and discrete gust content are accurately reproduced by the model. A parameter in the model enables intermittency to be controlled explicitly and matched to a variety of weather conditions and terrain. Experiments in a simulator have shown acceptance by pilots but credible simulation of turbulence and its effects requires a high quality motion system. The model exists as a FORTRAN computer program and as an analogue hardware device. Although originally concerned with pilot-in-the-loop simulation the model of turbulence described has relevance and application in other areas such as certification trials of automatic landing equipment. Author

**N76-29307** Technische Hogeschool Delft (Netherlands)  
**SIMULATION OF PATCHY ATMOSPHERIC TURBULENCE BASED ON MEASUREMENTS OF ACTUAL TURBULENCE**

G A J VanDeMoesdijk / In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 14 p refs

Pilot dissatisfaction with the characteristics of Gaussian simulated turbulence in flight simulation stimulated a research program to determine the relevant non-Gaussian aspects of actual atmospheric turbulence needed in a realistic turbulence simulation. A model describing the so-called patchy characteristics of atmospheric turbulence as sensed by the pilot is developed in which the degree of patchiness is defined in mathematical terms. Results of actual measurements of patchy characteristics analyzed in a method indicated by the model are compared to the model characteristics. Finally a digital simulation of real-time patchy turbulence velocities is presented. Author

**N76-29308\*** National Aeronautics and Space Administration  
Langley Research Center, Langley Station Va  
**INTERACTIVE COMPUTERIZED AIR COMBAT OPPONENT**

Walter W Hankins, III / In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 9 p

CSSL 01C

A computer program developed to fly interactive one-on-one simulated air combat maneuvers against human pilots is described. The program which is called Adaptive Maneuvering Logic (AML) is being used in the National Aeronautics and Space Administration (NASA) Langley Research Center's Differential Maneuvering Simulator. The basic control logic evaluates the relative states of the two aircraft and reacts by choosing the best of several elemental maneuvers. Pilot comments and results obtained when

the computer was flown against combat-qualified fighter pilots indicate that the program performs realistic maneuvers and offers a very competitive standard pilot Author

**N76-29310** LTV Aerospace Corp., Dallas, Tex  
**AIR COMBAT MANEUVERING TRAINING IN A SIMULATOR**

Charles W. Meshier and Gregory J. Bulter (Tactical Air Command Langley AFB Va) In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 10 p refs

The Tactical Air Command Aerial Combat Engagement Simulation (TAC ACES) is an attempt to use a fixed-base visual fighter simulator as a training device to improve combat skills. The program is structured to optimize the amount of training with simulation state of the art such that it will enhance the flight syllabus not replace it. The trainer configuration was developed from a review of U.S. industry and National Aeronautics and Space Administration (NASA) facilities. Instructional facilities were added to permit comprehensive monitoring of simulated combat with appropriate controls. In addition, a system of automated grading is provided summarizing each student's performance through the use of a digital computer-produced printout and finally, to teach the course a flight training syllabus was developed for the simulator. Pilot skills, safety and potential savings are tangible assets of course but the more subjective opinions of pilots and instructors are sampled too. Author

**N76-29311** McDonnell Aircraft Co., St. Louis, Mo  
**APPLICATION OF MANNED AIR COMBAT SIMULATION IN THE DEVELOPMENT OF FLIGHT CONTROL REQUIREMENTS FOR WEAPON DELIVERY**

J. B. Berger, R. P. Meyer and David L. Carleton (AFFDL) In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 20 p refs  
 (Contract F33615-73-C-3122)

Manned air combat simulations were conducted to develop requirements for tactical advanced aircraft/weapon systems in which precision tracking and weapon delivery are optimized through flight control system design. The objectives were to (1) develop analytical pilot models that relate weapon delivery accuracy to the entire integrated aircraft/displays/sight/geometry system for air-to-air and air-to-ground weapon delivery tasks; (2) validate and incorporate these pilot models into the Terminal Aerial Weapon Delivery Simulation (TAWDS) digital computer program; and (3) use the TAWDS program to determine how aircraft flying qualities affect air-to-air gunnery, and air-to-ground gunnery and bombing weapon delivery effectiveness. The TAWDS program enables a digital simulation to be performed on various closed loop weapon delivery systems under manual tracking control for predicting and evaluating weapon delivery accuracy. Tracking performance results acquired from analytical pilot simulations are compared with those obtained from the manned simulations and the Tactical Weapon Delivery (TWaD) flight test development programs. These results indicate that the judicious use of the all-digital analytical weapon delivery program in conjunction with manned simulation studies provides a very cost effective approach in designing, developing and optimizing advanced aircraft/weapon delivery systems. The evaluation of flying qualities for piloted advanced aircraft performing air-to-ground weapon delivery tasks in terms of weapon system effectiveness is shown to be feasible for determining and establishing flight control requirements. Author

**N76-29312** Litton Systems Inc., Woodland Hills, Calif  
**DEVELOPMENT OF A SYSTEM FOR SCORING SIMULATED BOMBING RUNS**

J. S. Ausman and F. J. Hellings (6585th Test Group) In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 19 p ref

A Bomb Scoring System (BSS) to be used in evaluating radar bombing capabilities of F-111 and A6 aircraft was developed. The BSS consists of an inertial navigation system updated with precision range and range-rate measurements to a set of 2 to 4 ground transponders placed in close proximity to the target. A pod contains the airborne equipment (inertial navigation system

and range/range-rate interrogator) and attaches to a standard weapon station on the aircraft. While the aircraft makes its (simulated) bombing run, the BSS pod continually monitors its position and velocity relative to the target. The aircraft's weapon delivery system sends its release pulse to the weapon station which holds the BSS pod. Subsequently, the computer predicts where the bomb would have landed if one had actually been released. Bomb impacts and other pertinent data are stored in memory for immediate readout when the airplane returns to base. Author

**N76-29313** Dornier-Werke GmbH, Friedrichshafen (West Germany)

**WASI WEAPON AIMING TRAINING SIMULATOR INSTALLATION**

Uwe Schulz In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 10 p

An inflight training system for the squadron training of pilots is defined. The system provides realistic training in ground attack with simulated bombs, cannons and rockets on a range or in tactical settings without the restrictions normally imposed by safety considerations: shortage of training ammunition, lack of availability of live firing ranges, etc. The system is self-contained within a standard modified drop-tank (WASI-POD) with the absolute minimum of mechanical and electrical interfaces. It provides an immediate indication to the pilot of miss distance and direction, while the most important parameters of the action are recorded on tape for subsequent play-back and analysis on the ground equipment. The WASI is suitable for basic training, refresher training, as well as continuous realistic tactical training. A detailed description of the system is given including some aspects concerning the future applications in the training for the air-air firing and dog fights. Author

**N76-29314** Royal Netherlands Air Force, The Hague  
**PROFICIENCY TRAINING OF PILOTS AND CONTROLLERS PARTICIPATING IN RNLAFF MISSIONS BY THE USE OF A SIMULATOR**

J. Alwon In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 4 p

Simultaneous training of pilots and mission controllers by coupling a ground-based simulator with a radar control center is reported. The flight training simulator is briefly described. Results of pilot training and mission controller simulation are given. J M S

**N76-29315** Ministry of Defence, London (England)  
**RESEARCH INTO THE TRAINING EFFECTIVENESS OF A FULL MISSION FLIGHT SIMULATOR**

Graham Shepherd In AGARD Flight Simulation/Guidance Systems Simulation Jun 1976 17 p

The training effectiveness of flight simulators is examined. An objective measure of aircrew performance is developed for use in long term streaming trials. Interim results for a number of flight profiles indicate the feasibility of deriving an objective measure of performance from recorded flight data and instructor assessments using linear multiple regression techniques. Author

**N76-29372#** Naval Research Lab., Washington, D.C.  
**HIGH PERFORMANCE COMPOSITES AND ADHESIVES FOR V/STOL AIRCRAFT** Progress Report, 1 Jul - 31 Dec 1975

Willard D. Bascom and Luther B. Lockhart Jr. Feb 1976 58 p refs

(Contracts NRL-Proj. C04-10 SF54903201)  
 (AD-A022331 NRL-MR-3223) Avail NTIS CSCL 11/4

An interdisciplinary program has been undertaken to address the composite and adhesive materials requirements of V/STOL aircraft. The primary tasks are to develop and characterize high-temperature and high-toughness resins, fabricate graphite-fiber reinforced composites, develop composite failure criteria for design optimization and establish quality control parameters. GRA

**N76-29407#** Army Materials and Mechanics Research Center, Watertown, Mass

**EROSION AND FATIGUE BEHAVIOR OF COATED TITANIUM ALLOYS FOR GAS TURBINE ENGINE COMPRESSOR APPLICATIONS Final Report**

Milton Levy and Joseph L. Morrossi Feb 1976 21 p

(DA Proj 1T1-62105-AH-84)

(AD-A022344 AMMRC-TR-76-4) Avail NTIS CSCL 11/6

The erosion and fatigue behavior of several potentially protective coatings for reducing the severity of sand erosion degradation of titanium alloys was studied. The coatings can be ranked in the following order of decreasing merit incorporating erosion indices at 30, 60 and 90 degrees impingement: titanium carbonitride (nickel interlayer), titanium diboride (nickel interlayer), boron carbide diffusion-bonded electroless nickel plus overlay of chromium diffusion-bonded electroless nickel and plasma-sprayed boron. All coatings caused fatigue strength reductions of between 22% and 80%. Shot peening reduced fatigue degradation in some cases. GRA

**N76-29416#** Dayton Univ. Research Inst., Ohio

**EVALUATION OF MATERIALS FOR AIR FORCE SYSTEMS AND HARDWARE APPLICATIONS Final Contract Report, 1 Jan 1974 - 31 Dec 1975**

W. E. Berner and G. J. Petrak Wright-Patterson AFB, Ohio AFML Feb 1976 297 p refs

(Contract F33615-74-C-5024, AF Proj 7381)

(AD-A022275 UDRI-TR-75-49 AFML-TR-76-1) Avail NTIS CSCL 11/6

This report summarizes the evaluation of a variety of materials and related engineering studies completed under contract to the Materials Support Division of the Air Force Materials Laboratory. It is divided into two sections, one covering mechanical properties of structural materials and the other the evaluation of nonstructural materials. Included in the first section are studies involving the crack resistance of B-1 materials and the evaluation of a landing gear side brace which were conducted in direct support of Air Force systems. Other more general studies were conducted on 7475 and X2040 aluminum alloys, Ti-6-4 and Ti-6-6-2 annealed forgings, beta processed titanium and D6ac steel. The second section of the report describes in detail a comprehensive test program to evaluate elastomeric ground water seals for missile silos. High temperature sealants for use in F-111 and C-130 aircraft fuel tanks were also evaluated. Another program discussed involves the evaluation of O-ring packings in a dynamic test mode. Two structural adhesives were evaluated to determine their performance in a high temperature, high humidity environment. The final program discussed involves the evaluation of thermoplastics for use as rotating bands on 20mm projectiles. A total of eighteen injection molded thermoplastic materials were evaluated along with eleven adhesives and four primers. Results of the screening tests (falling dart type) as well as actual gunfire testing are discussed. Author (GRA)

**N76-29419\*#** San Jose State Univ., Calif., Dept. of Chemistry

**STUDY OF THERMAL STABILITY AND DEGRADATION OF FIRE RESISTANT CANDIDATE POLYMERS FOR AIRCRAFT INTERIORS Final Report, Aug 1975 - Jul 1976**

Ming-ta S. Hsu Jul 1976 33 p refs

(Grant NSG-2093)

(NASA-CR-148567) Avail NTIS HC \$4.00 CSCL 11D

The thermochemistry of bismaleimide resins and phenolphthalein polycarbonate was studied. Both materials are fire-resistant polymers and may be suitable for aircraft interiors. The chemical composition of the polymers has been determined by nuclear magnetic resonance and infrared spectroscopy and by elemental analysis. Thermal properties of these polymers have been characterized by thermogravimetric analyses. Qualitative evaluation of the volatile products formed in pyrolysis under oxidative and non-oxidative conditions has been made using infrared spectrometry. The residues after pyrolysis were analyzed by elemental analysis. The thermal stability of composite panel and thermoplastic materials for aircraft interiors was studied by thermogravimetric analyses. Author

**N76-29429#** Bureau of Mines, Pittsburgh, Pa. Safety Research Center

**SUMMARY OF IGNITION PROPERTIES OF JET FUELS AND OTHER AIRCRAFT Final Report, 1 Jul 1974 - 1 Jul 1975**

J. M. Kuchta Wright-Patterson AFB, Ohio AFAPL Sep 1975 62 p refs

(Contract F33615-74-M-6251, AF Proj 3048)

(AD-A021320 AFAPL-TR-75-70) Avail NTIS CSCL 01/2

This report was prepared at the request of the Air Force to summarize the various ignition properties of jet fuels and other aircraft combustible fluids. The initial part is devoted to theory and definitions that are pertinent to ignition phenomena and the application of any experimental data. Other parts of this report summarize the various data that are available on ignition energies, ignition quenching distances and ignition temperatures of aircraft fuels, engine oils, hydraulic fluids and lubricants. Data are presented on the following types of ignition sources: Electrical sparks or arcs, frictional sparks, heated vessels or tubes, heated wires or rods, heated metal targets, jets of hot gases, shock wave and adiabatic compression, incendiary ammunition and self-heating. Author (GRA)

**N76-29596#** Polish Academy of Sciences, Warsaw

**COMPLEX STUDIES OF THE EFFECT OF TECHNOLOGICAL FACTORS ON THE PHENOMENON OF SEIZING IN SELECTED MACHINE ELEMENTS [BADANIA KOMPLEKSOWE WPŁYWU CZYNNIKÓW TECHNOLOGICZNYCH NA ZJAWISKO ZACIERANIA SIE WYBRANYCH ELEMENTÓW MASZYN]**

Edward Romanowski 14 Jun 1975 172 p refs In POLISH Avail NTIS HC \$6.75

The goals of the study were to investigate the causes of seizing in the cylinder sleeves of airplane piston engines of the ASz-62IR type to deepen the level of understanding of the phenomenon of seizing in cylinder sleeves of internal combustion engines, especially of airplane piston engines, and to seek ways of increasing resistance to seizing in such engines. Theoretical considerations based on a critical analysis of the current state of knowledge as well as new investigations are presented. The causes of seizing are thoroughly explained in light of which concrete proposals for its prevention are offered. Author

**N76-29615#** Shaker Research Corp., Ballston Lake, N.Y. **PNEUMOMECHANICAL CRITICAL SPEED CONTROL FOR GAS TURBINE ENGINE SHAFTS Final Report, May 1974 - Sep 1975**

Warren D. Waldron and Robert S. VanHuysen (Teledyne CAE, Toledo, Ohio) Sep 1975 148 p refs

(Contract F33615-74-C-2040, AF Proj 3048)

(AD-A021427 SRC-75-TR-13, AFAPL-TR-75-86) Avail NTIS CSCL 21/5

The object of the subject program was to further evaluate the application of gas-lubricated foil bearings to control high-speed turbomachine shaft critical speeds and/or amplitude of excursion. The work was intended to expand upon previous efforts by (1) incorporating a simulated H.P. rotor to house the intershaft foil bearings such that various interaction effects could be assessed and (2) evaluating a tension type foil intershaft bearing. A two rotor test rig which simulated the dynamic characteristics of a two spool aircraft gas turbine engine for testing tension type foil intershaft bearings was designed and constructed. Test results demonstrated that the simulated L.P. rotor could be operated through the region of the second critical speed with the foil intershaft bearings installed, whereas it could not if the foil bearings were not installed. Furthermore, the foil bearings attenuated all rotor amplitudes between the first and second critical speeds. Detrimental interaction effects between high and low speed rotors were not observed. GRA

**N76-29620#** Sandia Labs., Albuquerque, N.Mex.

**ALGORITHM FOR DETERMINING SURVIVAL PROBABILITIES FOR SYSTEMS WITH REDUNDANT COMPONENTS**

C. C. Carson Dec 1975 15 p refs

(Contract AT(29-1)-789)

(SAND-75-0444) Avail NTIS HC \$3.50

A simple and efficient algorithm for computing the survival probabilities for systems with redundant components (e.g., tactical aircraft in an AAA environment) is presented. The basis for construction of the algorithm and discussion of various aspects of it are included. Author (ERA)

**N76-29628#** Air Force Systems Command Wright-Patterson AFB, Ohio

**EXPERIMENTS WITH THE STATISTICAL TESTING OF THE FATIGUE LIFE OF MODEL SPECIMENS**

Jan Drexler 27 Jan 1976 12 p refs Transl into ENGLISH from Zpravodaj Vzlu (Czechoslovakia) no 1 1973 p 27-31 (AD-A020348 FTD-ID(RS)I-2458-75) Avail NTIS CSCL 14/2

This article provides practical information obtained by using graphonumerical statistical tests of the results of fatigue tests on model specimens of aircraft structures. The concrete case of the evaluation of the service life of tested specimens on Weibull probability paper supplemented by a nomogram, for determining the parameters of shape and position is presented. GRA

**N76-29650#** Massachusetts Inst of Tech, Cambridge Aeroelastic and Structures Research Lab

**FRACTURE MECHANICS ANALYSIS OF AN ATTACHMENT LUG Interim Technical Report, May - Oct 1974**

Oscar Orringer Jan 1976 92 p refs (Contract F33615-74-C-3063, AF Proj 1367) (AD-A021280, ASRL-TR-177-1 AFFDL-TR-75-51) Avail NTIS CSCL 01/3

This report documents a finite-element analysis procedure for computation of Mode 1 and Mode 2 stress intensity factors associated with a sharp crack in an attachment lug detail. The procedure is a complete FORTRAN-4 program which generates and parametrically analyzes the lug, based on designer-oriented input data. The formulation of a special crack-containing element is reviewed and its performance is summarized. A detailed description of the lug analysis procedure covers the physical problem, modeling, program flow and options, input/output conventions, execution times and limitations which must be observed. Results from example analyses of some attachment lugs are presented. GRA

**N76-29660** Messerschmitt-Boelkow-Blohm G m b H, Munich (West Germany)

**INTERACTION BETWEEN AIRCRAFT STRUCTURE AND COMMAND AND STABILITY AUGMENTATION SYSTEM**

O Sensburg In AGARD Structural Identification on the Ground and in Flight Including Command and Stability Augmentation System Interaction Jun 1976 p 41-53 refs

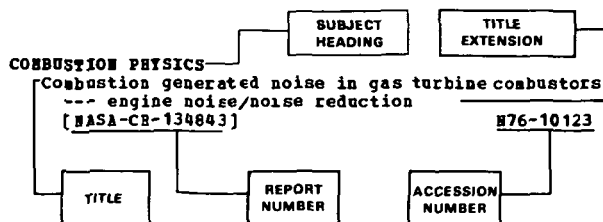
The multi role combat aircraft - MRCA - has a fly-by-wire control system and automatic stabilization. The sensors for the command and stability augmentation system - CSAS - are attached to the flexible aircraft structure and may therefore pick up signals which are detrimental to the stability. This paper describes the method which was used on the MRCA to avoid CSAS- structural mode coupling effects. Author

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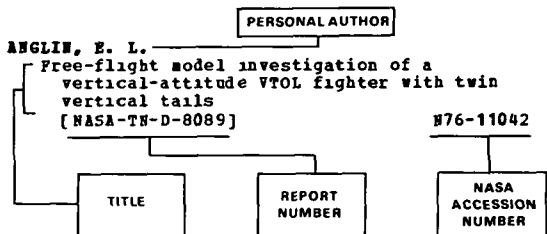
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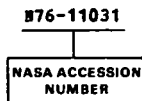
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